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THESIS

A DECISION SUPPORT STRATEGY FOR THE
ACQUISITION OF CVN Q-COSAL
TARGET DATE MATERIAL

by

William C. Small

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Thesis Advisor: Keebom Kang

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This thesis examines existing inventory management policies at the Supervisor of Shipbuilding, Newport News, VA. (SUPSHIPNN). It provides a decision support system called the DSS Strategy model. The results of simulation indicate inventory managers at SUPSHIPNN can use the DSS Strategy model to make decisions that will reduce inventories and meet production target dates.

Successful management of inventories is not a cost saving measure alone. The judicious use of valuable inventory and associated resources will maintain the fleet in the highest possible state of readiness within constricting fiscal resources.

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A Decision Support Strategy for the Acquisition of CVN Q-COSAL Target Date Material

by

William C. Small
Lieutenant, Supply Corps, United States Navy
B.S., University of North Carolina at Wilmington, 1980

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requirements for the degree of

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ABSTRACT

In response to the reduced threat against the United States, Congress has directed the Department of Defense (DOD) to reduce spending. As funds are reduced, targets of opportunity are shifting from the battlefield to the appropriation field. Dollars invested in inventories are a prime target of cost reduction.

This thesis examines existing inventory management policies at the Supervisor of Shipbuilding, Newport News, VA. (SUPSHIPNN). It provides a decision support system, called the *DSS Strategy* model. The results of simulation indicate inventory managers at SUPSHIPNN can use the DSS Strategy model to make decisions that will reduce inventories and meet production target dates.

Successful management of inventories is not a cost saving measure alone. The judicious use of valuable inventory and associated resources will maintain the fleet in the highest possible state of readiness within constricting fiscal resources.

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I. INTRODUCTION

The Supervisor of Shipbuilding, Conversion and Repair, USN (SUPSHIP), is the on site Naval representative at the privately-owned Newport News Shipbuilding and Dry Dock Co. (NNS&DDCo). The personnel of SUPSHIP administer the contracts associated with the construction, overhaul, and master ship repair at NNS&DDCo. Of major importance to SUPSHIP personnel is the adherence of the contractor to the production schedule stipulated in the construction contract. The goal of the SUPSHIP Integrated Logistics Support (ILS) Department in the area of material management is to have material on hand well before scheduled production requirements. They consider the costs associated with the construction, overhaul, and repair to substantially exceed all other costs, including the investment and holding costs of inventory. Consequently, to meet production goals, secondary importance is assigned to the costs of inventory and material management.

The Defense Management Review and Government Accounting Office reports have discussed the need for the Department of Defense (DOD) to control inventory cost and reduce the size of inventories. Further, the reduction of the previous Soviet threat and the congressionally mandated force reduction are now placing increasing fiscal constraints on inventory and

material management. Therefore, the philosophy of SUPSHIP inventory and material management must reflect the current political and fiscal climate.

The material requirements for new construction vessels are determined by the Naval Sea Systems Command (NAVSEA). The material requirements arise from the provisioning process. The provisioning responsibilities and relationships are provided in Figure 1.

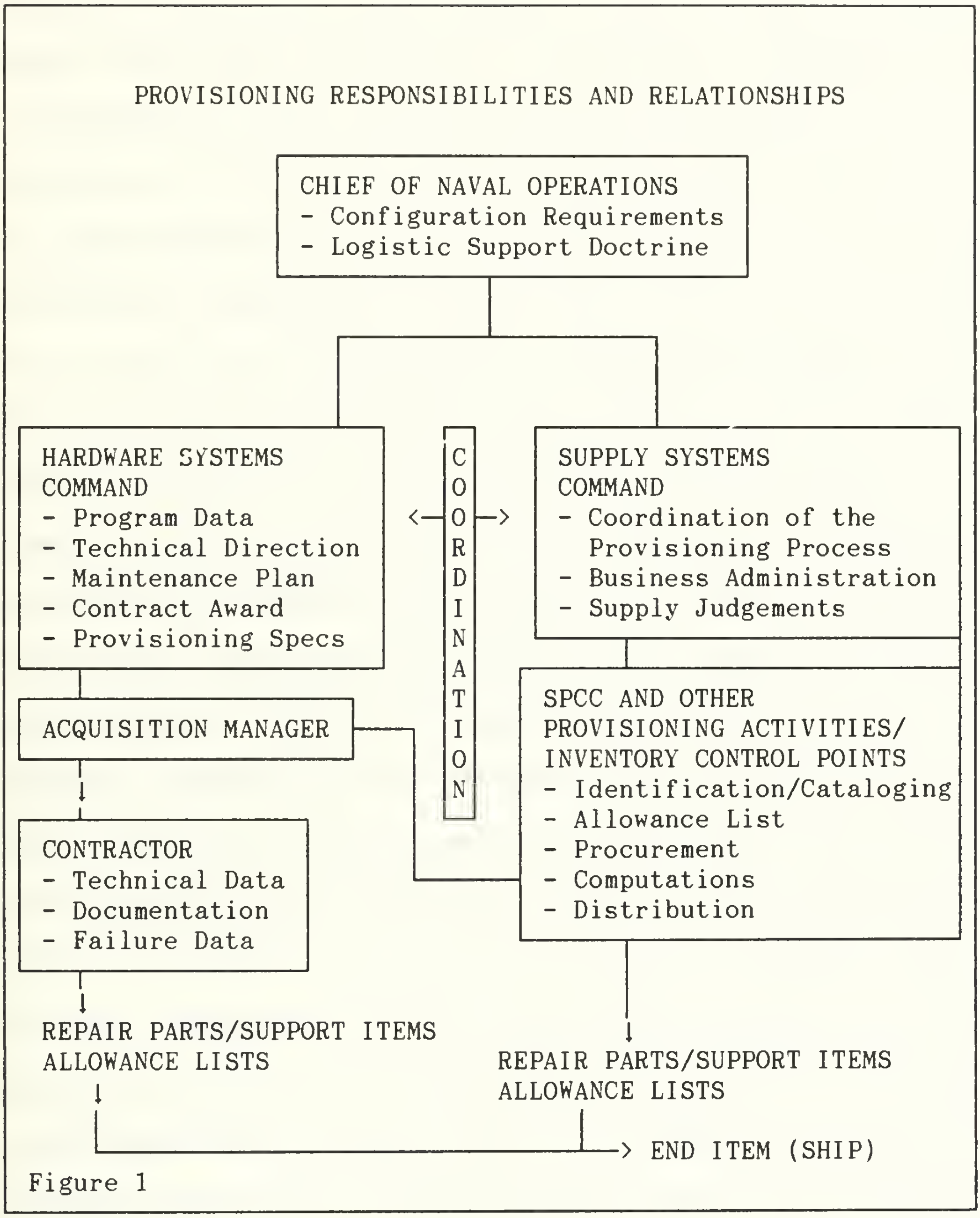


Figure 1

The provisioning process determines the range and depth of repair parts and equipage (e.g. high dollar value, pilferable items) that are required to provide initial support material for an end item (i.e., new construction vessel). As depicted

in Figure 1 [Ref.1:p.31], Ships Parts Control Center (SPCC) and contractors involved in supplying material prepare allowance lists that describe the type and quantity of material required for the vessel. These lists, include the Allowance Part Lists (APL) and Allowance Equipage Lists (AEL) and are included in the ship tailored allowance document, the load Coordinated Shipboard Allowance List (COSAL). The publication of the COSAL is accomplished incrementally by SPCC and forwarded to the SUPSHIP. Therefore, in reality the printing and forwarding of the COSAL is the triggering mechanism for SUPSHIP to begin ordering material listed in the COSAL. In effect, the material management and inventory process is driven by printing of the COSAL by SPCC and the receipt of the COSAL by SUPSHIP. This process is scheduled with the goal of providing SUPSHIP with sufficient lead time to order material in advance of production requirements.

The COSAL for naval ships is divided by material category. The division results in a document containing several parts that will be tailored to ship type and installed equipments. For nuclear powered vessels, a separate COSAL is prepared for the material requirements that are required to support the nuclear propulsion plant(s) and associated equipment. This allowance document is called the Q-COSAL. The material that is dedicated to support nuclear propulsion is identified by a special material identification code (SMIC)

within the National Stock Number (NSN). The NSN is the military part number assigned for the identification of parts.

During the new construction period, the material requirements will change. Improvements in technology, changes in the perceived threat, safety considerations, and fiscal constraints may justify the addition or deletion of various material. This environment of change causes inventory growth. Items that are no longer required are generally held in inventory until the completion of construction. This accumulation of unnecessary material increases the inventory holding and disposal costs.

The personnel involved in production planning and material acquisition must coordinate their efforts to reduce inventory levels while providing the required material support. The potential cost savings that could be obtained by eliminating the holding cost for a nuclear aircraft carrier for one year is approximately nine million dollars. [Ref.2] With more coordination and teamwork, material will be available to meet production demands and excess material can be returned to the fleet for more efficient use. By implementing a decision support system (DSS) for inventory and material management at SUPSHIPNN, the Navy will benefit in two ways. One, the Navy will enjoy cost savings by reducing inventory cost; two, the fleet readiness will improve because of the efficient use of resources.

A. THE MISSION OF THE SUPERVISOR OF SHIPBUILDING, CONVERSION AND REPAIR, USN.

The primary mission of the Supervisor of Shipbuilding, Conversion and Repair, USN, Newport News (SUPSHIPNN) is to administer Navy contracts within the privately-owned shipyard, NNS&DDCo. SUPSHIPNN is the on site representative of NAVSEA. NAVSEA has the overall responsibility for the construction and maintenance of Navy vessels. It assigns SUPSHIPNN (also all other SUPSHIPS) with tasks and functions that are suitable with the capabilities of the facility. The SUPSHIPNN tasks and functions are: [Ref.3:p.ii]

1. Providing logistic support to activities and units of the Operating Forces of the U.S. Navy and naval shore (field) activities, as assigned by competent authority.

2. Performing authorized shipwork in connection with the construction, conversion, overhaul, repair, alteration, activation, inactivation and outfitting of naval ships and service craft.

3. Performing authorized repairables work in connection with repair, restoration, refit, refurbishment and overhaul of systems, equipments, components and modules as scheduled.

4. Designing naval ships, when so designated.

5. Operating as planning yard for ship alterations and preparing allowance lists for ships under construction and conversion in accordance with instructions issued by NAVSEA.

6. Performing research, development, test and evaluation work, as assigned.

7. Serving as stock point for designated material, as assigned.

8. Providing accounting civil payroll, savings bond, public works, industrial relations, medical, dental, berthing, messing, fire prevention and fire protection, security and other services to naval shore (field) activities and other government agencies, as assigned.

9. Performing manufacturing, as assigned.

10. Accomplishing shore-electronics work; as requested by the Naval Electronic Systems Command.

11. Preparing and maintaining development, logistic support, disaster control and other plans, as assigned.

12. Performing work for other U.S. Government Departments, private parties and foreign governments, as directed by competent authority.

Many of the above described tasks are not actually performed by SUPSHIPNN, but are performed by NNS&DDCo. SUPSHIPNN monitors NNS&DDCo to ensure contractor compliance and quality assurance. SUPSHIPNN does play a significant role in material acquisition and inventory management. The Integrated Logistics Support Department of SUPSHIPNN is responsible for the material acquisition of all vessels under the cognizance of SUPSHIPNN.

B. RESEARCH OBJECTIVES.

This thesis will attempt to formulate a decision support model that will enable the SUPSHIPNN inventory manager to obtain material, minimize costs, reduce inventories, and meet production target dates. The study will determine the factors that contribute to inventory growth during the construction of

a Naval vessel. It will provide a methodology to reduce the future investment required in maintaining shipbuilding inventories.

The subset of material required for the construction of a nuclear powered aircraft carrier (CVN), Q-COSAL, will be used to present the philosophy and implementing methodology. It represents an easily identifiable portion (via use of the SMIC code) of material required during the construction of a CVN. The Q-COSAL material can provide a clear path of material flow and inventory position for study and analysis.

The benefits of using a DSS that reduces inventory requirements will be identified and discussed during subsequent chapters. The goal of the study, and the presentation of the DSS is to provide the material and inventory manager with a decision making tool (the DSS Strategy model). This tool, when combined with the experience of the manager, will significantly reduce shipyard inventories. The decision support system will be consistent with the philosophy of providing the Navy with ships that meet delivery schedules at a minimum cost.

C. SCOPE OF THE STUDY.

This thesis will focus on the SUPSHIPNN manager's dilemma in material acquisition and inventory growth. It will provide an analysis of pertinent qualitative issues involving target

dates and production deadlines. To aid the decision process, the thesis will include the use of quantitative techniques to provide realistic guidance for material and inventory management. The goal of the DSS and the DSS Strategy model is to reduce the penalties/costs associated with either early or late material acquisition. Current management policy and local actions previously taken to more efficiently use inventory and reduce growth will be included. Alternatives not currently in use or previously considered will be proposed and evaluated.

D. LIMITATIONS.

The problems associated with material requirements and inventory management are evident throughout DOD. This thesis will not attempt to address the global forum. Due to limitations of time and scope, it will address the problems associated with Q-COSAL material requirements and inventory reduction.

SUPSHIPNN was selected for study because the author envisions that within the constraints of time and finances, a meaningful study can be conducted with realistic data. The CVN was selected because it represents a large inventory investment and is, in the author's opinion, an excellent candidate for the proposed decision support system.

E. ORGANIZATION.

Chapter I introduces the missions and goals of SUPSHIPNN. It describes the provisioning relationships and responsibilities and material requirement determination. Additionally, the use a DSS within the existing SUPSHIP organization is presented in this chapter. The anticipated impact of the DSS is inventory reduction, cost reduction, inventory accuracy, and better utilization of resources.

Chapter II provides a review of the acquisition philosophy. Discussions include the policies affecting requisition priorities, material flow, and inventory management. An overview is presented of the CVN construction process. This overview examines allowance and material requirements and validates the magnitude of the inventories used to support production. The use of the Just-In-Time (JIT) philosophy is reviewed within the framework of the proposed DSS. The advantages of inventory reduction and benefits are described in this chapter. Problems associated with the growth of shipyard inventories are examined through the results of previous studies and reports.

Chapter III reveals the methodology used for the study. The use of models and simulation techniques are discussed in this chapter. The DSS Strategy model and the validation model are presented in this chapter. The model and simulation applications against available data are presented and

discussed. The types of data, how data was gathered, and to what extent it was relied upon is also considered.

Chapter IV contains an analysis of the results of the data supporting the use of the DSS Strategy model. The implications of the analysis in support of the DSS Strategy model and inventory reduction are presented in Chapter IV. Specific inventory reduction levels are examined and a review of safety stock considerations are presented.

Chapter V summarizes the results of this study. It offers a DSS Strategy model example that demonstrates the opportunities for inventory and material managers at SUPSHIPNN to reduce the Q-COSAL inventory.

II. BACKGROUND

A. ACQUISITION POLICY.

The primary goal of the SUPSHIPNN material acquisition policy is to avoid production delays. To accomplish this high level of protection, material is ordered as funds are available and requirements are known. The material and inventory personnel at SUPSHIPNN operate under the assumption that a production delay would be more expensive than inventory and holding costs. The focus of the production and inventory personnel is not on inventory costs. The costs associated with inventory are considered minor in comparison to the costs associated with delaying the vessel. Consequently, the inventory levels at NNS&DDCo have continually grown since mid-1980. [Ref.4:pp.7-15]

As the budget realities of the 1990's have begun to constrain all facets of the DOD, emphasis is expanding to include analysis of all costs. Readiness at any cost is no longer a working philosophy. The question may now be, how much readiness can be achieved within a given budget? Personnel involved in material acquisition are experiencing increased scrutiny from oversight activities such as the Government Accounting Office (GAO) and Congress. As discretionary funds become scarce, competition for these funds

will increase.

Funding has not been the only resource subject to reduction. The number of personnel employed by DOD is also being reduced. The number of personnel available for managing material and inventory will be less than previously employed. Thus, those remaining personnel must be used as efficiently as possible.

The objective of this study is to examine the potential of a DSS that provides the inventory or material manager with the opportunity to reduce inventories. To be considered successful, the DSS should reduce inventories and minimize the risk of a delay in production due to material shortage.

The main focus of this study is to investigate the inventory flow of the Q-COSAL material and to define the specific applications of the DSS. This research includes current methods of material acquisition for the initial outfitting of the CVN. A macro review was conducted of the major material flows and inventories to gain an awareness of the magnitude of the material and inventory processes. The study encompassed receipt flows, intermediate stowage and mock-up, and ultimately the installation of the material on board the ship. A mock-up consists of material awaiting storage on board the ship. The mock-up replicates the bins and racks used on board the ship and are fabricated from wood

and cardboard. The study commenced with the development of the initial load COSAL and terminated with the commissioning of the vessel.

The process of initial outfitting (provisioning of a new vessel) is considered critical on nuclear vessels. NNS&DDCo and the SUPSHIPNN together represent the government and industrial interest in the management of initial outfitting material. The technical requirements of the reactor operations and weapons delivery systems dictate that the crew, unlike on conventional platforms, arrive approximately two and one half years before the commissioning of the vessel.

CVN crews have significant latitude in incorporating changes to the ship's allowance documents (see Table 1).

TABLE 1
CVN ALLOWANCE DOCUMENTS

Allowance Document	Coverage
COSAL	Ship's on board spare parts
AVCAL	On board parts used to support air wing
AMAL/ADAL	Medical/Dental allowance items
GUCL	General use consumable
Q-COSAL	On board parts to support nuclear reactor(s)

All of the listed documents may be changed to incorporate advances in technology, reliability, or other changes. Changes may be in the form of increases, decreases, or editorial.

Allowances for each major system depicted in Table 1 are determined by various methods. For example, the COSAL allowances are determined mainly by a modeling process. However, the material flow is generally generic in nature and is portrayed in Figure 2. The baseline ship configuration data drives the type of equipment that will be installed on board each vessel. The configuration as compared to mission, criticality, and modeling decide the piece part support for the ship.

MATERIAL AND REQUIREMENTS FLOW FOR NEW CONSTRUCTION VESSELS (EXISTING SYSTEM)

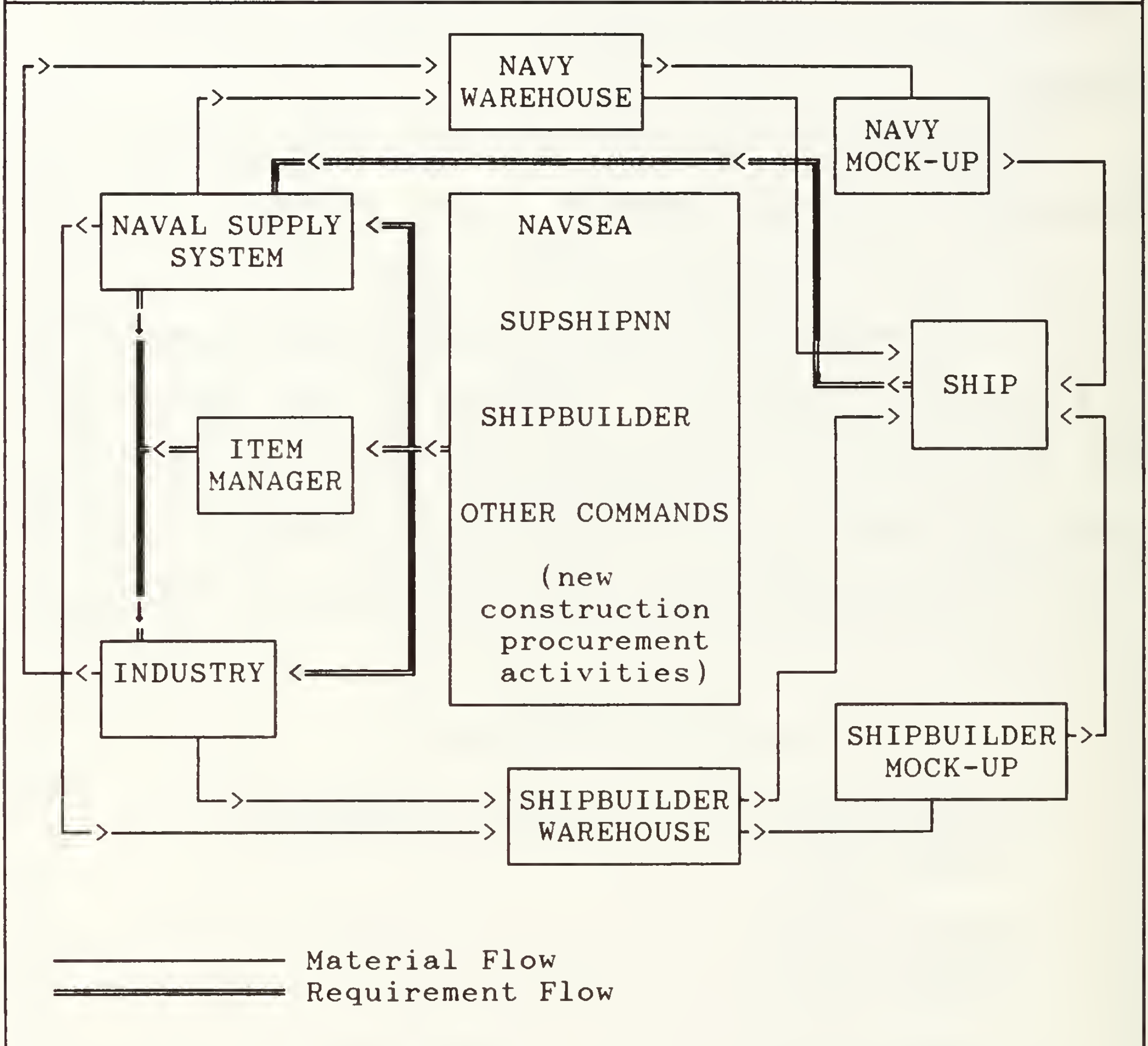


Figure 2

The Q-COSAL allowances are determined by the equipment manufacturer(s), primarily General Electric and Westinghouse, in concert with NAVSEA. Approximately 75% of the Q-COSAL material is "pushed" to NNS&DDCo for use/installation on board

the ship. "Push" material is sent to the ultimate user from the cognizant agency without any intervention from the end user. The remaining Q-COSAL material is ordered by SUPSHIPNN. [Ref.2]

The biggest handicap affecting initial provisioning of an aircraft carrier, besides its size and complexity, is the tremendous length of construction time. Once the ship is authorized, the configuration data can be determined. Then, the various procurement commands (SUPSHIPNN, Shipbuilder, NAVSEA, SPCC, Aviation Support Office (ASO), and others) obligate their funding. It is possible for some allowance material to be on hand at the construction site several years before loading. [Ref.4:p.1] This action leads to waste as the configuration of the ship can change during construction, or the material can be damaged or stolen. Additionally, the shipyard will incur higher inventory costs, which it passes on to the Department of the Navy. The AVCAL is affected to a lesser extent because the majority of AVCAL material is requisitioned at the end of the construction period.

The development of the Incremental Stock Number Sequence List (ISNSL) has caused the shipbuilder and the Navy to buy large quantities of repair parts for several ships at once. The "quantity discount" rationale combined with a "must use available funding before it expires or is moved to another program" drives the acquisition of large quantities of repair

parts. Additionally, the level A configuration of the Weapons System File may not accurately reflect the revised conditions of a new construction vessel. This can mislead the shipbuilder in the procurement process. Shipbuilding contracts require the shipbuilder to furnish an initial range and depth of spare and repair parts for contractor supplied equipment. If the material is procured for a configuration that ultimately changes, the shipbuilder and the Navy may procure parts for which there is no requirement, and may do so in extremely large quantities.

An additional concern of initial provisioning is consumable items with a shelf-life. "O" rings, photo processing chemicals, gasket material, and especially Q-COSAL material consisting of chemicals are susceptible to loss by expiration if received too early in the provisioning cycle or if the platform experiences significant delay in delivery.

The biggest loser of initial outfitting may be government furnished materials (GFM). The Navy provides GFM directly to the contractor for use in construction, testing, or storage within the ship upon completion of its respective storeroom.

According to GAO, the Navy does not know how much GFM is in the contractor's possession because there are no general financial or other management systems to account for these materials. No person or office is either responsible or accountable for the overall protection of the Government's

investment in the GFM the Navy provides the contractor. [Ref.4:pp.15]

Newport News was found guilty of these many accounting and inventory errors:

1. Two transducers valued at $5,460 were listed on contractor's records as transferred to a shipyard shop, but five years later, were still in the contractor's warehouse. Neither the Navy nor the contractor knew they were there.

2. An isolator, valued at $3,500, was not included on the excess GFM list submitted to SUPSHIPNN. A year later, it was still in the warehouse. Neither the property administrator nor the contractor had caught the error.

3. Several items which SUPSHIPNN had ordered to be disposed of, were still in the contractor's warehouse three years later.

4. Twenty-two hand sets, valued at $3,354 each, had no warehouse location listed on the contractor's records.

GAO summarized the procurement process as being convoluted to the point where responsibility and

accountability were severely lacking. Because no single command is responsible for the overall management of the procurement of the carrier's initial spare parts outfitting, there is little financial accountability. With various commands procuring initial provisioning materials, and with no control guidance, waste and abuse of the procurement dollar is to be expected.

As a Naval Audit Service report indicates: [Ref.5:p.18]

> In the past, procurement lead time (PLT) has not been considered a phase of the provisioning process. Rather, PLT was viewed as a part of the contracting function only (PLT is the period of time required for contract preparation, acceptance, manufacture and delivery of an item). As procurement lead times have generally increased, the need to broaden the perception of the provision process and manage both allowance determination and allowance material acquisition was recognized. For complex weapons systems the full provisioning process frequently exceeds thirty-six months.

B. PRODUCTION AND SCHEDULING.

The integrated logistics support (ILS) concept manages all aspects of procurement. Ideally, the philosophy includes "cradle to grave" management of each piece of major equipment.

Support, training, and technical documentation are included in the process. To manage the ILS concept at the SUPSHIPNN level, an Integrated Logistics Support Management Team (ILSMT) is formed. The ILSMT consists of procurement, allowance, and production personnel. The team is used to provide management attention at the end user level. The forum presents an excellent opportunity for the sharing of information between the production and acquisition communities. Information on production problems, or accelerated production, is vital to the material management personnel. Additionally, major changes that will add or delete material may be used by inventory and material management personnel to aid in inventory reduction. Production personnel require information regarding potential or actual material problems.

Three major allowance documents drive the initial outfitting of the ship. The carrier's COSAL consists of approximately 90,000 line items valued at approximately $44 million. The carrier's AVCAL has approximately 30,000 line items valued at approximately $25 million. Allowance levels supporting the reactor plants are contained in the Q-COSAL. [Ref.2]

As shown in Table 2, the ship will be fitted out with a specified percentage of material. The material varies by category; however, the implications of this requirement are severe. By mandating the percentage of Q-COSAL items to 100%,

NAVSEA has implicitly assigned every material requirement with a level of criticality that may not be realistic. Material that is redundant in quantity, or in reality not truly critical (i.e., mission degrading), is procured and if necessary, expedited as a truly critical item. Within the framework of the proposed DSS, a distinction between truly critical and other material is highly recommended. The NAVSEA requirements for initial outfitting are reflected in Table 2. [Ref.6:p.123]

TABLE 2

NAVSEA OUTFITTING REQUIREMENTS FOR NUCLEAR VESSELS AT FAST CRUISE

Allowance Document	Coverage	% Required on Board
COSAL	Ship's on board spare parts (OBRP) (SRI) (OSI)	97
AVCAL	On board parts used to support air wing-test benches	*
AMAL/ADAL	Medical/Dental	97
GUCL	General Use Consumables	97
Q-COSAL	On board parts to support reactor(s) (OBRP) (IN-USE)	100

* 100% on order, no requirement for on hand.

The current method for obtaining the required support defined in the allowance documents is portrayed in Figure 2.

Requirements from Naval sources enter the Naval Supply System via the nearest Supply Center. If possible, the requirements will be satisfied from Navy stock. Unsatisfied requirements are generally in the following two forms:

1. Not in stock (NIS), item(s) normally carried in the supply system, but current stocks are exhausted. An estimated delivery date is provided on the back order status.

2. Not carried (NC), item(s) which are not carried in the supply system. For new construction assets, an inventory manager will attempt to open purchase the item, or refer the item to a contracting officer for contracting action.

SUPSHIPNN employs incremental release of requirements into the supply system. One reason for the incremental release is financial in nature. Another reason for the incremental release is related to the printing of the allowance documents by SPCC. Until the documents are printed and forwarded to SUPSHIPNN, requisitioning of material generally will not occur. Although Ship Construction and Conversion, Navy (SCN) funds are five year appropriations, NAVSEA apportions the funds in annual increments to SUPSHIPNN. This allows NAVSEA flexibility in funding shipbuilding

projects under its cognizance.

Requisitions also will be submitted to the Naval Supply System from NNS&DDCo. In the case of sophisticated electronic equipment, Q-COSAL, and SUBSAFE items, the Naval Supply System is normally the only procurement source for the shipbuilder. Requisitions are submitted to the system with the lowest force activity designator (FAD), urgency of need designator (UND), and priority used in the supply system. The result is that routine initial outfitting requirements inherently become long lead time items. Two exceptions to this are:

1. Q-COSAL material, used in support of the reactor plant may be ordered with a normal fleet FAD and UND of "B" (mission degrading) and priority "6" (urgent requirement).

2. Safety and navigation aids, and certain commanding officer designated items may be converted to the higher UND and priority, six weeks before fast cruise.

The crew of each vessel, under the direction of the Supply Department, is responsible for submitting requirements under their cognizance to the supply system during the initial outfitting process. The CVN supply department will be involved in procurement. They will decide requirements, order

the GUCL, all habitability items, Q-COSAL "in use" items, and office machines.

C. INVENTORY MANAGEMENT.

The CVN inventory management process is extremely complicated. By virtue of the magnitude and diversity of equipment requiring support, the material must be requisitioned to satisfy both scheduled production and shipboard inventory requirements. Arriving requirements from the supply system/vendor are classified and flow as follows:

1. Nuclear material (special receipt and handling). The amount of Q-COSAL "in use" material is significant and requires immediate delivery to the ship. Reactor testing and operation require that critical material be on board and the contractor must ensure the material is received expeditiously by ship's force. "In use" material will be picked up from the contractor warehouse and delivered to the ship by ship's force.

2. Ship's force material. GUCL and habitability items are received by the contractor at the central receiving point and separated and held for pick-up by ship's force personnel. Ship's force is responsible for stowage on board the vessel. The volume prohibits direct delivery to the ship. Therefore, material will be shipped to an off-site Navy warehouse for

receipt processing and stowage until the ship is ready for the material.

3. AMAL/ADAL medical supplies. For the CVN, the contractor will not receive AMAL/ADAL material, nor will he provide environmental storage for this material. A special routing identifier on the requisition normally directs all material to the off-site Navy warehouse where it will be stored until the medical spaces can accept the material. Because the Navy warehouse does not provide special environmental storage, material requiring special storage is shipped to NSC Norfolk for storage.

4. COSAL material. Generally, on board repair parts that the contractor will ultimately load on board the vessel.

5. AVCAL material. Material required to support the air wing and the test equipment used in repair and to perform preventive maintenance. AVCAL material poses unique problems to the CVN. The determining factor (that is, what type(s) and mix of aircraft will be carried on board the vessel) remains unsolved usually until the last few months of construction. Since the known requirements are received by ship's force from ASO late in the delivery cycle, segregation into categories and ordering of material is not as susceptible to change. The material is shipped (as with AMAL/ADAL) with a routing

identifier that attempts to send the material to a special receipt area at Norfolk Naval Air Station. The material is placed in a mock-up that has been constructed by ship's force. When the storerooms are prepared on the ship, the material is transferred to the ship and stowed in its proper location.

With early and complete ILS implementation, tradeoff analysis for equipment design will fulfill operational needs while minimizing support requirements and life cycle costs.

Further, the program may benefit from the incorporation of a Just-In-Time (JIT) procurement and inventory concept. [Ref.7:p.230] With the proposed DSS, a revised procurement, receipt, mock-up and stowage chart (Figure 3) graphically shows the advantages of the JIT concept. JIT is a delivery concept (normally associated with Japanese manufacturing) that seeks to dramatically reduce inventory and storage and handling costs. Implementation of JIT into the initial outfitting process would require a close working relationship between the procurement entities (SUPSHIPNN, NAVSEA, etc.), the item manager, and the vendors (industry and the Naval Supply System).

MATERIAL AND REQUIREMENTS FLOW (PROPOSED SYSTEM)

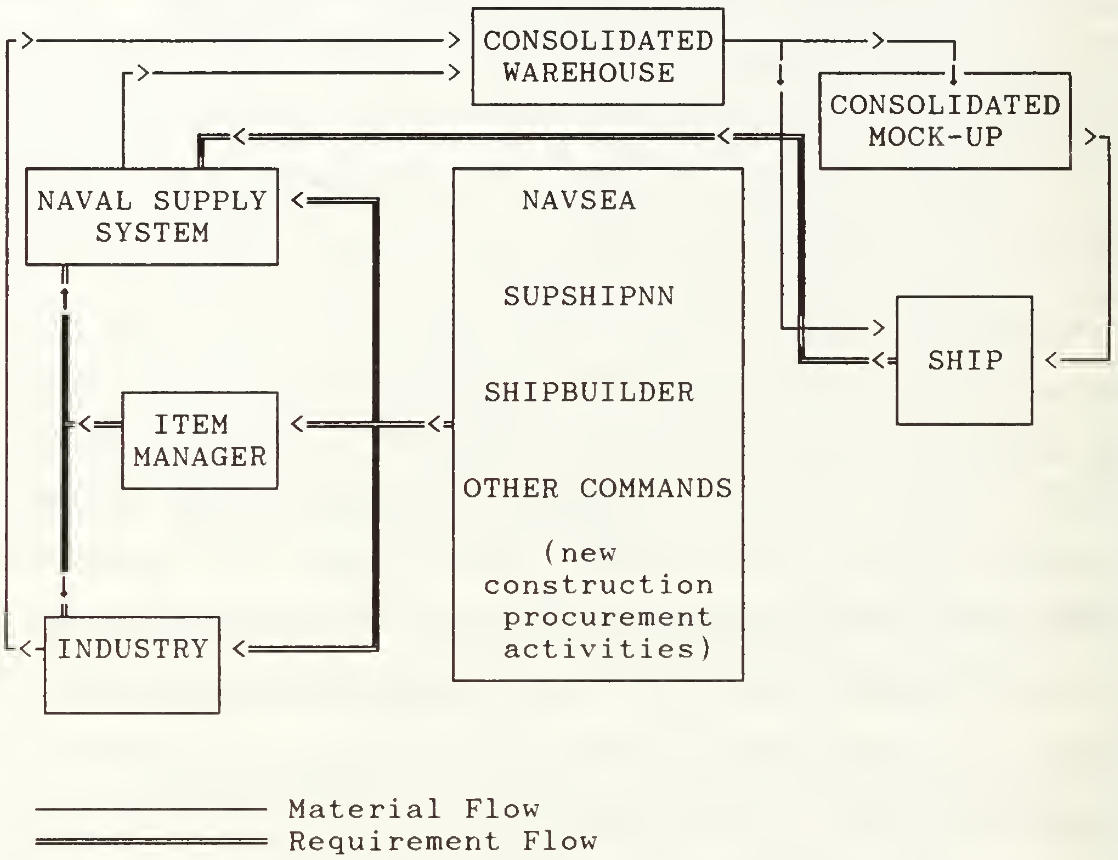


Figure 3

In order to implement JIT four elements are necessary:

- reduced order quantities
- frequent and reliable delivery schedules
- consistent lead time
- consistently high quality levels of purchased materials

These elements consider that purchasing begins the material flow cycle. This allows suppliers to deliver materials frequently to the consolidated warehouse or directly to the mock-up.

A successful JIT concept reduces the suppliers workload for a specific period and lowers both supplier and buyer inventory costs. Because materials are received "Just-in-Time", additional benefit is gained in the combination of receipt and issuing documentation and a savings in record keeping.

Establishment of good rapport with the vendor is primary to development of a JIT inventory and delivery schedule. A vendor capacity plan (contract), expanding on blanket order techniques and purchase orders with schedules, though difficult to establish, would prove beneficial. Requirements for a vendor capacity plan are: [Ref.8:p.229]

- a vendor willing to allow loading of his plant capacity to match requirements
- precise purchase orders with clear contract details
- releases based on a master schedule and/or the material requirements planning system (e.g., allowance documents)
- weekly and daily JIT deliveries

In effect, the vendor capacity plan, combined with JIT, result in purchasing orders with very special scheduling efforts.

In addition to the close working relationships developed, a successfully implemented JIT program will provide the following benefits:

- few or sole source suppliers
- long-term contracts with suppliers
- steady production schedules with frequent, but gradual and well-communicated, changes
- purchased materials at standard or in supply bins sent directly to the consolidated warehouse, mock-up, or ship
- design of parts, specifications, and quality closely coordinated
- statistical process control charts furnished by the vendor would eliminate the need for receiving inspections
- delivered quantities represent only a few days requirements, reducing warehouse storing costs.

The JIT inventory philosophy can reduce inventory costs because of minimum inventory investment and associated carrying costs. For the initial outfitting process, the DSS and JIT philosophy would reduce consolidated warehouse storage time, paperwork, and overhead costs.

D. INVENTORY COSTS.

DOD Instruction 4140.39 defines various elements of inventory costs. In addition, SUPSHIPNN management personnel must consider other costs that must be controlled if the overall inventory cost is to be reduced. The investigation of inventory costs is considered necessary to provide managerial focus on the benefits of inventory reduction within the DSS. Costs are one of the universal measures of effectiveness. Cost reduction, while maintaining protection levels against production delays, is the framework of the DSS.

The most elusive cost examined is the shortage cost. The shortage costs, as viewed within the DSS, are the penalty for not having material when required to meet scheduled production. The variable nature of the shortage cost is based upon the criticality of an individual item. The shortage cost depends on the average number of days forecast for delay in the availability of material and the availability of funds for inventory investments [Ref.9:p. 2]. Other factors are commonly used by inventory and procurement personnel to capture the true costs associated with shortages. These costs may include idle labor and facilities and down-stream production problems.

Administrative ordering costs are the costs associated with the ordering of material. These costs include processing the order, material receipt, and storage. The JIT philosophy

would seem to increase administrative order costs because it dictates that minimal quantities be ordered. This is true only if the procurement is by purchase order contract. It is not generally true if material is procured from standard stock or from indefinite delivery contracts. The DSS assumes the prudent procurement manager will use the most cost efficient manner of procurement.

The elements of variable costs that reflect the monetary penalty for holding inventory are defined in DOD Instruction 4140.39 as follows:

> 1. <u>Investment cost</u>. The view taken toward the investment of funds in inventory is that each public dollar so invested represents a dollar of investment in the private sector foregone....An annual charge of *ten percent* of the average on-hand inventory will be made....
>
> 2. <u>Cost of losses due to obsolescence</u>. ....include losses of material due to all causes that render the on-hand material superfluous to need. Thus this element will include losses due to technological obsolescence, over-forecasting of use, and other causes....
>
> 3. <u>Other losses</u>. This element is intended to cover losses due to such causes as pilferage shrinkage, inventory adjustments, etc....
>
> 4. <u>Storage cost</u>. This represents both the "out-of-pocket" costs incurred in the keeping of inventory and the amortized cost of the storage facilities. The cost of storing the inventory itself includes: care of material in storage, rewarehousing costs, cost of physical inventory operations, preservation

> and packaging, training of storage personnel, cost of warehousing equipment and pro-rated base services and overhead costs. The sum of these annual costs divided by total average on-hand inventory...gives the "out-of-pocket" storage cost rate.... [Ref.9:encl. 4]

These cost elements are incorporated in the DSS in two general categories. First, what costs must be assessed to having materials before they are needed ($ per unit per day)? Second, what costs must be assessed to not having materials when they are needed ($ per unit per day)?

In procurement, lead time is generally uncertain. The key to inventory reduction is to minimize total overstocking and understocking costs. The ILSMT, using a DSS, would have the crucial information that is required to determine key events and decide the timing of material requirements. Inventory reduction can reduce material and inventory costs, while completing scheduled production during required time periods.

E. PREVIOUS STUDIES.

In September 1988 DOD reported it had $56.5 billion of government property with contractors. [Ref.10:p.13] During January 1988 GAO reported that the Navy's stock exceeded requirements by 24 to 30 months with a value of $14 billion. Further, the DOD inventory grew by 138 percent during the 1980's while DOD's unrequired inventory increased by 233 percent (from $1.1 billion to $3.7 billion [Ref.11:p.14]). In

their March 1990 report, GAO states: [Ref.10:p.3]

> DOD has inadequate controls over material and equipment furnished to government contractors. The services are buying spare parts before they are needed and are often not canceling orders for unneeded items.

Two of the recommended corrective actions that are applicable to this study are: [Ref.10:p.3]

> 1. The services need to establish annual goals for reducing existing inventory to minimize the overall vulnerability and abuse. The sheer size of the inventory complicates the management of an already cumbersome system.
>
> 2. Management incentives should discourage buying unnecessary inventory. DOD's inventory management attention focuses on filling orders within a specific time frame and timely obligation of funds. However, the services need to have a corresponding emphasis on reducing costs and promoting economy and efficiency.

One method currently employed by the Navy to reduce inventory levels at shipyards and other industrial areas is through the use of planned program requirements. Planned program requirements represent anticipated one-time demands such as

outfitting or altering of ships. The requirements are provided to inventory control points (ICP) for procurement prior to the anticipated need.

Another GAO report addressed the penalties of not having government material on hand when required by the shipbuilder. Of the 33 contracts the GAO analyzed, 23 contracts had major cost growth and schedule overruns that could be attributed to inadequate or late government material. The amount of claims against the Navy can be significant. For example, in the $28.2 million contract for the USS FIFE, the contractor was paid over $6 million for delays and disruptions. [Ref.12:p.17]

Within the private sector managers of large projects face the same challenges when attempting to minimize project costs while remaining on schedule. Ronen and Trietsch developed a DSS model for purchasing management of large products. [Ref.13] The DSS is applicable to this study because the model uses a stochastic, stationary inventory model which emphasizes the variability of lead time. The model minimizes total holding and lateness costs by optimizing ordering time. This is similar to the proposed DSS used in this study except the requirement for inventory and penalty costs are ignored.

Ballou [Ref.14:pp.477-488] in his discussion on acquisition and production scheduling decisions addresses the problem within the context of material requirements planning (MRP). He views the problem as how to determine how much

additional time must be planned in the order release cycle to protect against lead time uncertainties.

Ballou's and other similar models were generally considered beyond expertise of the personnel at SUPSHIPNN. The mathematical models require a knowledge of algebra and calculus, which is not a prerequisite for employment as an inventory or material manager at SUPSHIPNN. The data required to use the models may not appear complex in nature. However, SUPSHIPNN is at a private shipyard and obtaining accurate cost data from the contractor is difficult and is generally expressed as overhead costs. To obtain unit cost data in this environment may be too expensive (the contractor would require payment for furnishing data) and may not be accurate since the contracts are on a "cost plus" basis. The contractor does not have incentives to control costs within certain limits, the costs associated with the data may reflect the lack of cost control. The proposed DSS requires minimal data gathering and less rigorous mathematical skills. The premise of the DSS is that prudent reduction of inventory will yield benefits in associated areas, such as costs and resources. Therefore, the DSS does not place strong emphasis on cost reduction. The emphasis of the DSS is on inventory reduction.

III. METHODOLOGY

A. SIMULATION AND THE DSS.

The use of simulation for analysis of complex system problems is rapidly gaining the acceptance of management personnel. This section will discuss the use of simulation to model the material and inventory flows at SUPSHIPNN. The two models developed for this study will be presented later in this section. The reasons for developing the models are:

- Provide a method for validating the complex system (material and inventory flow) by using two independent models.
- Develop a tool which allows analysis of a complicated system.
- Provide a method of comparison between a model using on-screen animation and graphics, and a model that uses an on-screen spreadsheet.
- Develop a method for determining the probability of one or more outcomes occurring.
- Develop a model with probability distribution functions, that duplicate the type of uncertainty that is encountered in real world situations.

The two models developed for this study are:

1. Validation model. A validation model was developed using SIMFACTORY II.5. SIMFACTORY requires no programming; its use does require that the operator understand the system being simulated and the basic

concepts of simulation. SIMFACTORY can be used on most microcomputers. The validation model (using SIMFACTORY) uses on-screen animation and graphics to present the model. The use of on-screen animation and graphics allows the manager to observe the operation of the model as it changes over time.

2. The DSS Strategy model. The DSS Strategy model was developed using LOTUS 123 and @RISK. Like SIMFACTORY, no programming (other than usual spreadsheet formulas) is required. The DSS Strategy model requires minimal hardware and software for operation (LOTUS 123, @RISK, and 512K RAM). The DSS Strategy model allows the user to perform "What if?" analysis by varying cell values and distributions within the model spreadsheet. The output of the DSS Strategy model is in graphic displays and reports.

Graphical animation using microcomputers and interactive modeling allows managers to study, via use of simulation, present and proposed methods of system operation. Simulation allows managers to perform "What if?" analysis without disturbing the existing system. [Ref.15:p.1]

Recent advancements in simulation have begun to eliminate the requirement for the user to acquire special programming skills. Simulation software is now available that allows

managers to simulate their operation with minimal computer experience. To validate the DSS Strategy model, a simulation was conducted using SIMFACTORY II.5 (validation model) that uses menus to guide the formulation of the model. [Ref.15:p.iii]

The purpose of simulation is to model complex operational situations for which the solution may be either too rigorous analytically, or impossible to obtain. The DSS Strategy model incorporates the use of Monte Carlo simulation to model the outcome of uncertain events such as order processing time, material availability, and transportation.

B. OVERVIEW OF THE DSS STRATEGY MODEL.

The goal of the DSS Strategy model is to support the inventory or material manager in reducing inventory levels while meeting material requirements for scheduled production. Perhaps the strongest presumption of the model is that by reducing inventories, benefits of inventory reduction described in Chapter II will be realized. This does not imply that the DSS will provide the optimal benefit. However, it does imply that inventory costs will be reduced and that resources will be subject to more efficient allocation.

This strong presumption reduces the amount of data that is required for using the model. For example, cost reduction is not the prime focus of the model. Therefore, various cost

elements are not required. The model provides the inventory or material manager with a numerical estimate of the time frame for submitting requirements that will meet production schedules.

C. ASSUMPTIONS OF THE DSS STRATEGY MODEL.

1. All requisitions are submitted from SUPSHIPNN to the consumer level as a batch, on the same day. This assumption indicates that all requisitions will be accepted "as is," no errors are present in the documents, and appropriate funding for all requisitions is present.

2. Requisitions are processed by each subsequent station as they are received (subject to the assigned distribution).

3. Each requisition will be completely filled. No partial quantities will be assigned. This prevents a requisition from being split and filled at two or more stations.

4. The menus within the program sufficiently define the operation being performed.

5. All requisitions are passed to the next station without delay, using electronic methods. The exceptions are when a requirement is passed from the intermediate

level to the wholesale level and from the wholesale level to the factory. For this exception, the use of the U.S. mail was used in the model.

6. The 500 replications are sufficient to obtain realistic results.

7. Items will not be placed in a backorder status. Not in stock or not carried requisitions will be obtained from the manufacturer.

D. THE DSS STRATEGY MODEL.

The DSS Strategy model was developed using the LOTUS 123 spreadsheet (see Appendix A) and @RISK simulation. The data was obtained from SUPSHIPNN personnel and entered in the spreadsheet [Ref.16]. The model simulates the process of ordering, transporting, and receiving material by SUPSHIPNN from the Navy supply system. The LOTUS 123 spreadsheet is the vehicle for data input. To simulate the system, the @RISK software was attached as an "add in" to the LOTUS 123 software. The use of the @RISK "add in" extends the capabilities of the LOTUS 123 spreadsheet from a single estimate of the result to producing an estimate that is obtained from multiple replications of Monte Carlo simulations. The @RISK portion samples a large number of possible combinations by generating random variates and

produces a range of outcomes (simulation). The data used in the simulation for this study represents the SUPSHIPNN view of the Q-COSAL material flow at the time of the study. The data is summarized in Tables 3, 4 and 5.

TABLE 3
MODEL REQUISITION FLOW, DISTRIBUTION, AND PROBABILITY DATA
Source: SUPSHIPNN

Level	Distribution	Probability of Being Filled		
Retail	Triangular	95%	82%	75%
Intermediate	Triangular	95%	87%	75%
Wholesale	Triangular	95%	93%	75%
Manufacturer	N/A		100%	
Inventory	N/A		100%	
CVN	N/A		100%	

The triangular distribution (minimum, most likely, maximum) was used in model formulation. It is appropriate in circumstances where data is absent or for rough modeling [Ref.17:p.341]. The DSS Strategy and validation models are, due to the scope of this study, rough models. Further, data used in the models, such as transportation times from each activity, could only be approximated by SUPSHIPNN.

TABLE 4
MODEL REQUISITION PROCESSING TIME, DISTRIBUTION, AND PARAMETERS
Source: SUPSHIPNN

Level	Distribution	Value of Parameters (in days)
Retail to Intermediate	Triangular	.0416, .5, 1
Intermediate to Wholesale	Triangular	.0416, .5, 1
Wholesale to Manufacturer	Triangular	.0416, 3, 14
Manufacturer to Material	Triangular	.0416, 7, 30
Inventory	N/A	N/A
CVN	N/A	N/A

TABLE 5
MODEL MATERIAL FLOW PROCESSING TIME, DISTRIBUTION, AND PARAMETERS
Source: SUPSHIPNN

Level	Distribution	Value of Parameters (in days)
Retail to Inventory	Triangular	1, 10, 30
Intermediate to Inventory	Triangular	2, 14, 30
Wholesale to Inventory	Triangular	2, 14, 30
Manufacturer to Inventory	Triangular	2, 14, 30
Inventory to CVN	Triangular	3, 5, 7
CVN	Triangular	.5,.75, 1

The following three figures (Figures 4, 5, and 6) depict how data collected in Tables 3, 4, and 5 are assigned in the model. The requisition flow, requisition processing times, and material flows are portrayed as they are used in the model.

DSS Strategy Model
Using @Risk and Lotus 123
Requisition Flow

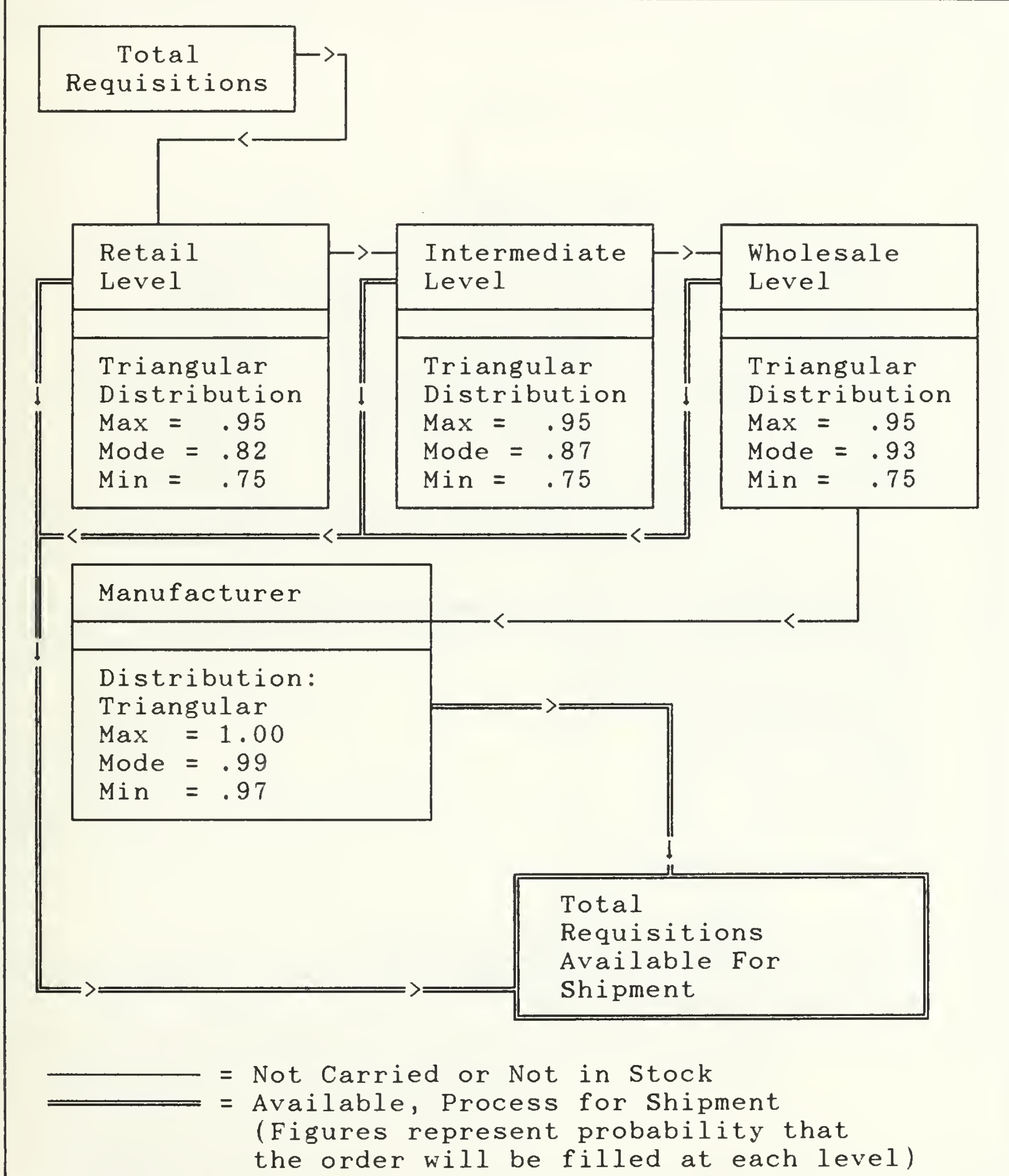
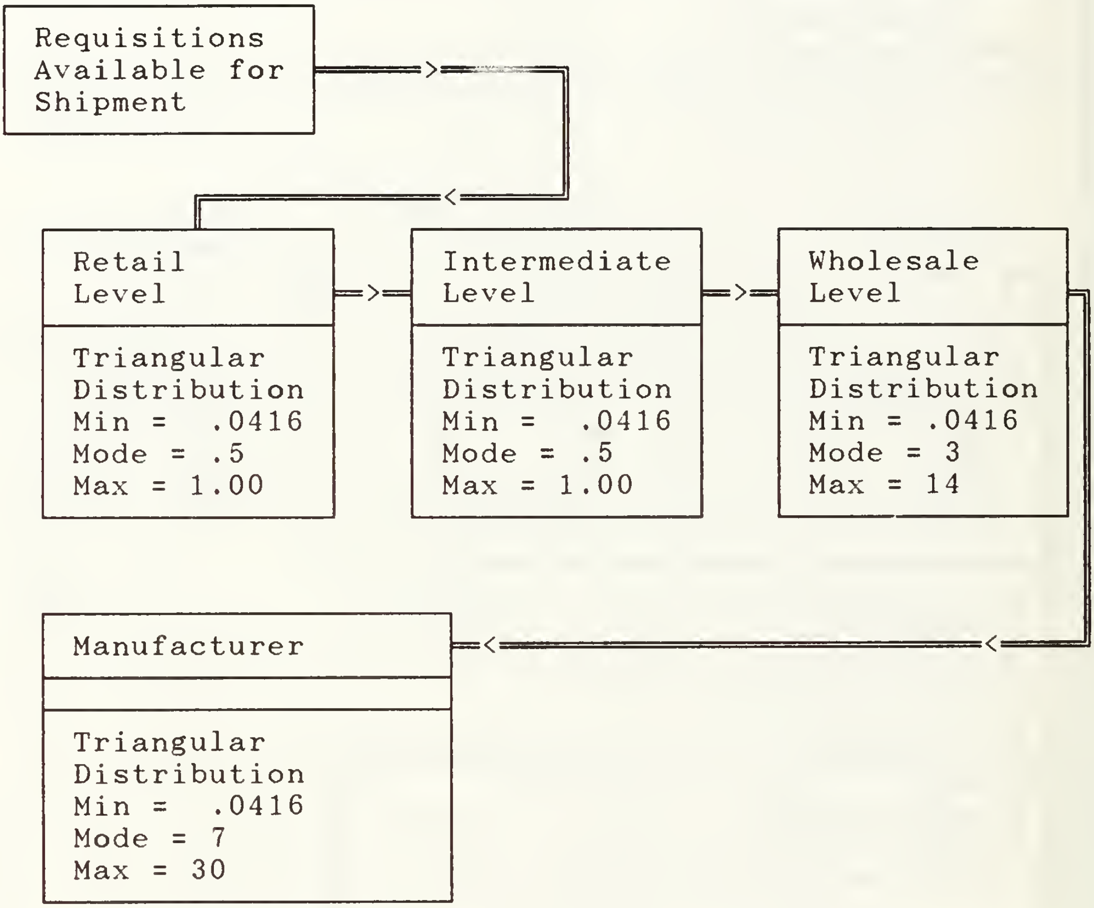


Figure 4

DSS Strategy Model
Using @Risk and Lotus 123
Requisition Processing Time, Distributions, and Flow



= From-to Processing Path
(Time is in Days)

Figure 5

DSS Strategy Model
Using @Risk and Lotus 123
Material Flow Processing Times and Distributions

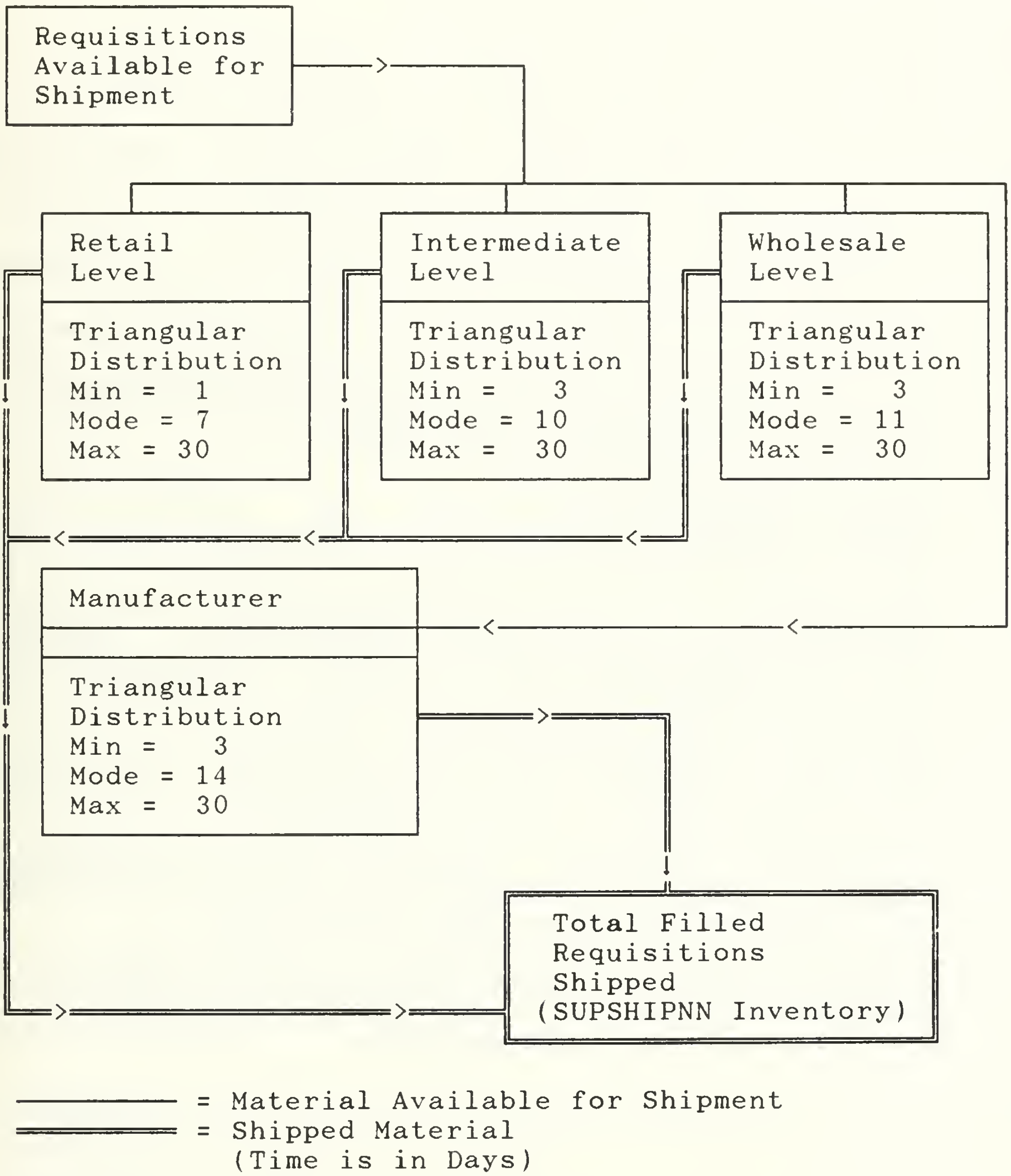


Figure 6

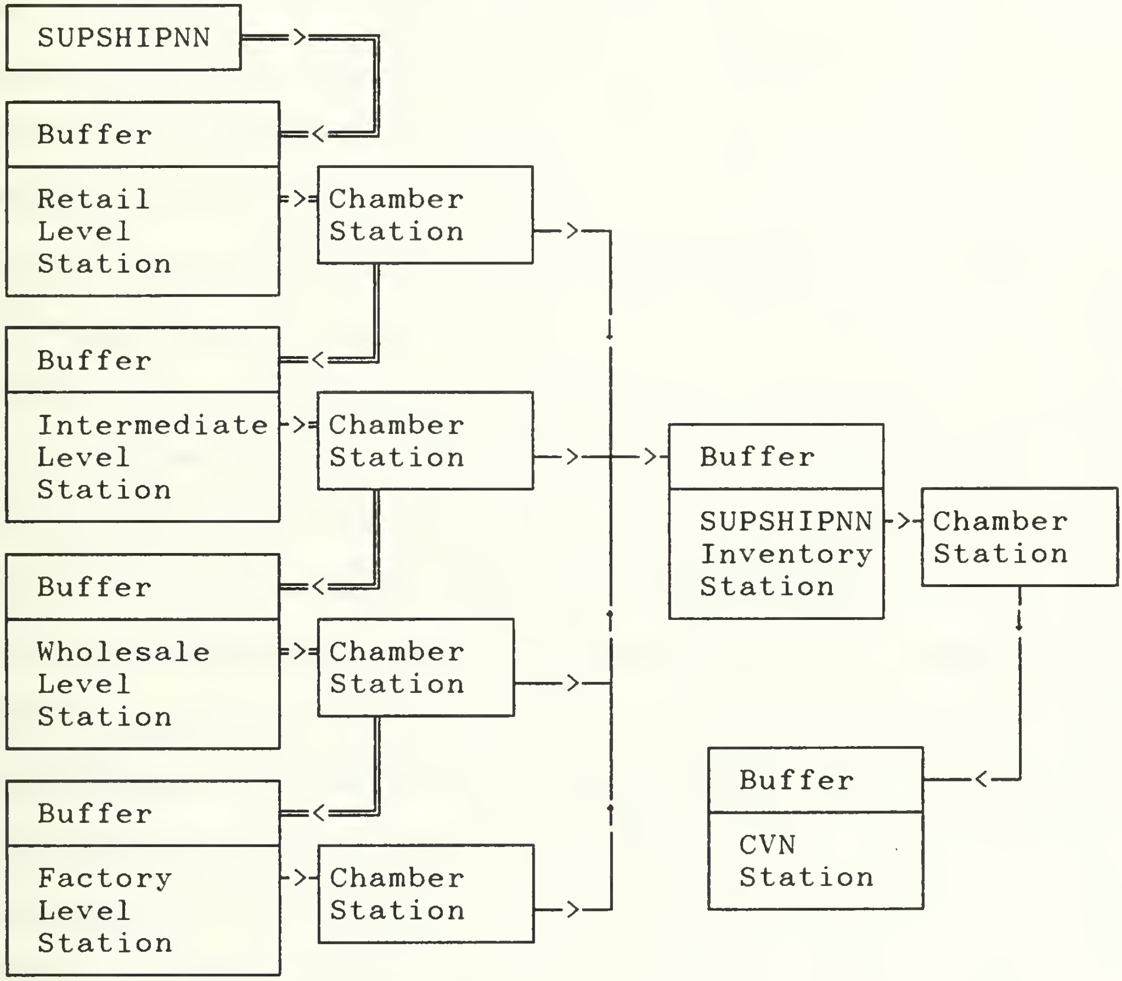
The results of the DSS Strategy simulation are discussed in Chapter IV. A sample output of the simulation is in Appendix A.

E. VALIDATION MODEL SIMULATION.

The validation model using SIMFACTORY replicates the order and material flow described in Chapter II. The model is a network of nodes through which elements flow and are transformed (i.e., requisition becomes material) according to a user-specified process. The model developed for this study is presented in Figure 7. The layout nodes are represented by the following: [Ref.15:pp.51.125.126]

> <u>Buffer</u>. Models a location where objects are stored while they await further processing.
>
> <u>Distribution</u>. A model of a random event. SIMFACTORY uses distributions to select values to use a inputs for various events, such as the time for an arrival or the quantity of items which are arriving.
>
> <u>Receiver</u>. A model of the location where raw material (requisition input) enters the model.
>
> <u>Station</u>. A location where an operation may occur. Stations typically model machines, work cells, or other physical objects where work is performed.
>
> <u>Chamber Station</u>. Chamber stations differ from normal stations in that they can operate on multiple parts simultaneously and independently.

VALIDATION MODEL
SIMFACTORY II.5 SIMULATION



——— = Shipped Material
═══ = Unfilled Requisition (passed to next activity)

Figure 7

The validation (SIMFACTORY) model used the same parameters as the DSS Strategy (LOTUS 123/@RISK) model (see Tables 3, 4 and 5).

The sample results of the validation simulation are presented in Appendix C. The use of the on-screen animation and graphics were useful in building and debugging the model. Due to slow processing of on-screen animation and graphics, the number of replications per simulation was limited to twenty. A replication is a single iteration of the model through a simulation. The model did verify that the required 150 requisitions were processed and requirements were delivered (using trial and error) within approximately 60 days. One of the limitations of the validation model is that it does not directly calculate a specific average delivery time. The model operates on a set simulation time and does not stop when the requisitions are completed. It stops when the simulation time is completed. Thus, it only verifies the possibility of the delivery within a given time period. The DSS Strategy model provided similar results, with an average delivery of the 150 requisitions to be approximately 58 days (details provided in Chapter IV).

F. ASSUMPTIONS OF THE SIMFACTORY SIMULATION.

The assumptions of the SIMFACTORY simulation are the same as those for the DSS Strategy model except for the following:

1. The assigned percentage of requisitions filled or passed to the next station will be used instead of using a (triangular) distribution.

2. The menus within the program sufficiently define the operation being performed.

3. The number of replications used is sufficient to obtain realistic results.

G. LIMITATIONS ENCOUNTERED USING SIMULATION.

For the validation and DSS Strategy models the constraints did suffice for an accurate representation of this study. The validation model "translates" the user-provided values (input) into a computer simulation language called SIMSCRIPT II.5. [Ref.15:p. 1] During simulation, this translation process uses considerable processing time. The use of animation during simulation also uses a significant amount of processing time. When animation and graphics were run during the simulation, the processing time was noticeably slower.

IV. ANALYSIS

A. CUMULATIVE OVERVIEW OF THE DSS STRATEGY MODEL.

The results of four simulation runs of the DSS Strategy model, consisting of 500 iterations each, were analyzed to determine the theoretical inventory position at SUPSHIPNN. The simulations consisted of 150, 300, 750, and 1500 requisitions. The 1500 requisitions typically represent the approximate maximum initial Q-COSAL requirements. The simulation runs using 750 requisitions represent the minimum number of initial requisitions, and 300 requisitions represent the maximum number of follow-on requirements. The 150 requisitions represent the minimum number of requirements that will be added or changed from the initial Q-COSAL. Figure 8 shows the cumulative distribution for the number of days required for 150 requisitions to flow through the supply system.

Based on 500 replications, approximately 60 percent of the requisitions were processed within 57 days. The minimum result was 22 days and the maximum result was 107 days, with a standard deviation of 16.50 days.

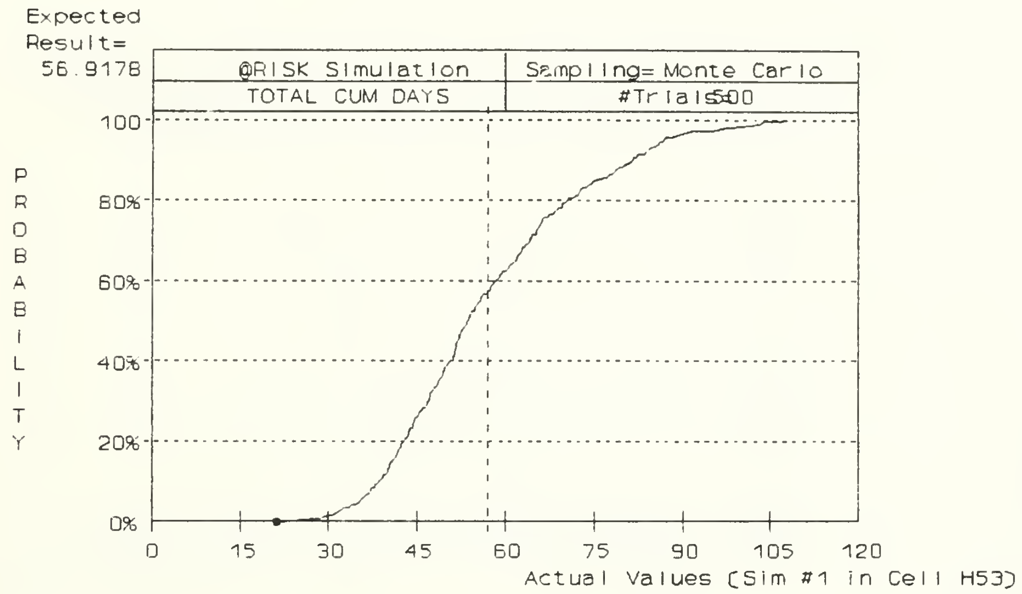


Figure 8
Cumulative Distribution for 150 Requisitions

Increasing the number of requisitions also increased the number of days required to complete the requisition cycle and have the material on hand. When requisitions were increased to 300, the average number of days increased from 57 days (for 150 requisitions) to 69 days (Figure 9). The maximum and minimum results were 18.5 and 117.5 days, respectively, with a standard deviation of 17.64 days.

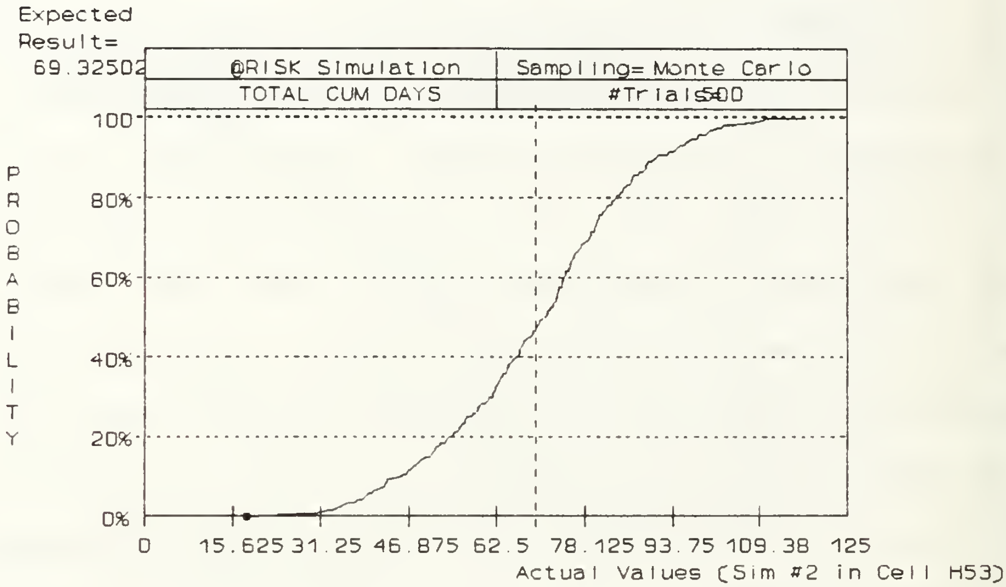


Figure 9
Cumulative Distribution for 300 Requisitions

When the number of requisitions was increased to 750 (Figure 10), and then to 1500 (Figure 11), the results of the DSS Strategy model indicated the cumulative number of days did not significantly change. The average days to complete 750 and 1500 requisitions remained approximately 76 days (75.8 for 750 requisitions, 76.4 for 1500 requisitions) with a 60 percent probability. The standard deviation for the two simulations was similar, 14.01 and 13.32 days, respectively.

The maximum result for both simulations was 118 days; however,

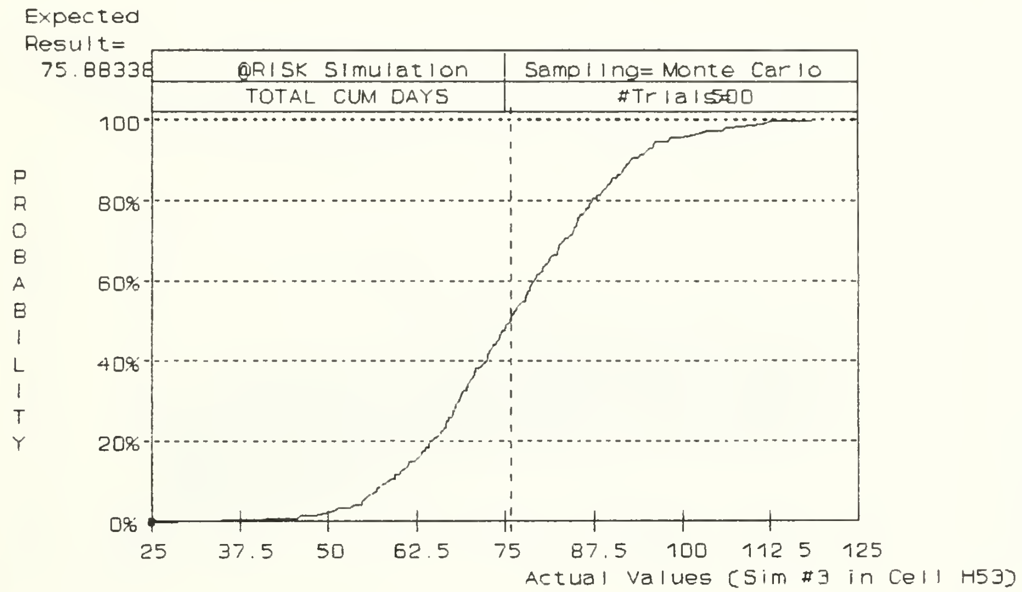


Figure 10
Cumulative Distribution for 750 Requisitions

the minimum result for simulation 3 (Figure 10) of 21.4 days differed from the minimum result for simulation 4 (Figure 11) of 42.5 days. The difference of approximately 21 days is most likely the result of the increased size of the population (number of requisitions) and the probability that values will be chosen that are closer to the extremes for the triangular distribution. The triangular distribution is weighted around the mode (most likely) instead of the mean. Thus, with the

smaller (150) number of requisitions, it is less likely that

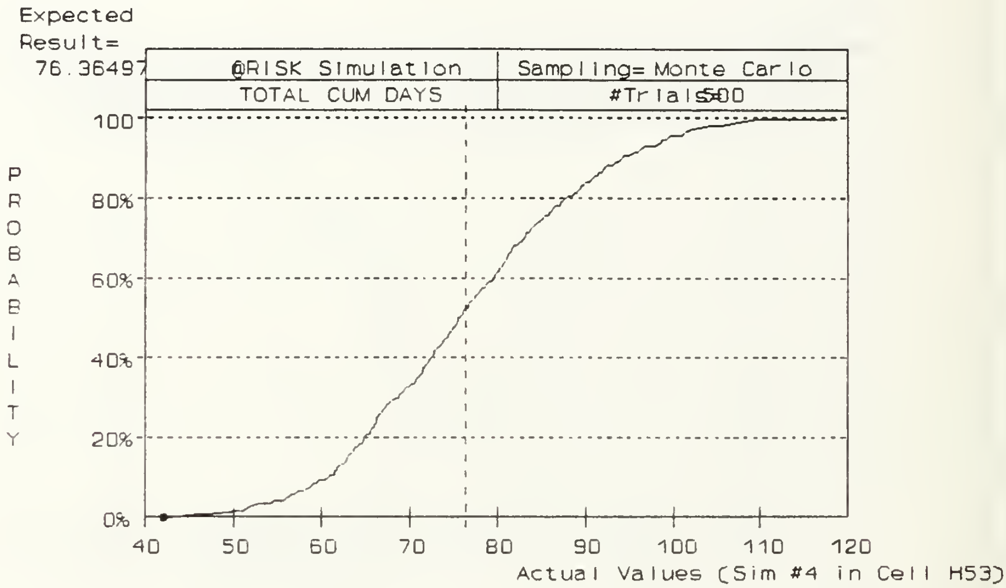


Figure 11
Cumulative Distribution for 1500 Requisitions

values near the extremes of the distribution will be observed. As the number of requisitions increase (1500), values near the extremes of the distribution will be observed with greater frequency. The inventory and material managers need to understand that the same fraction of requirements will be assigned to the extremes of the distribution, regardless of the number of the requirements. In others words, maximum or minimum values may not be visible in the model with a small

number of requirements, but will exist.

Figure 12 summarizes the results of all four simulation runs.

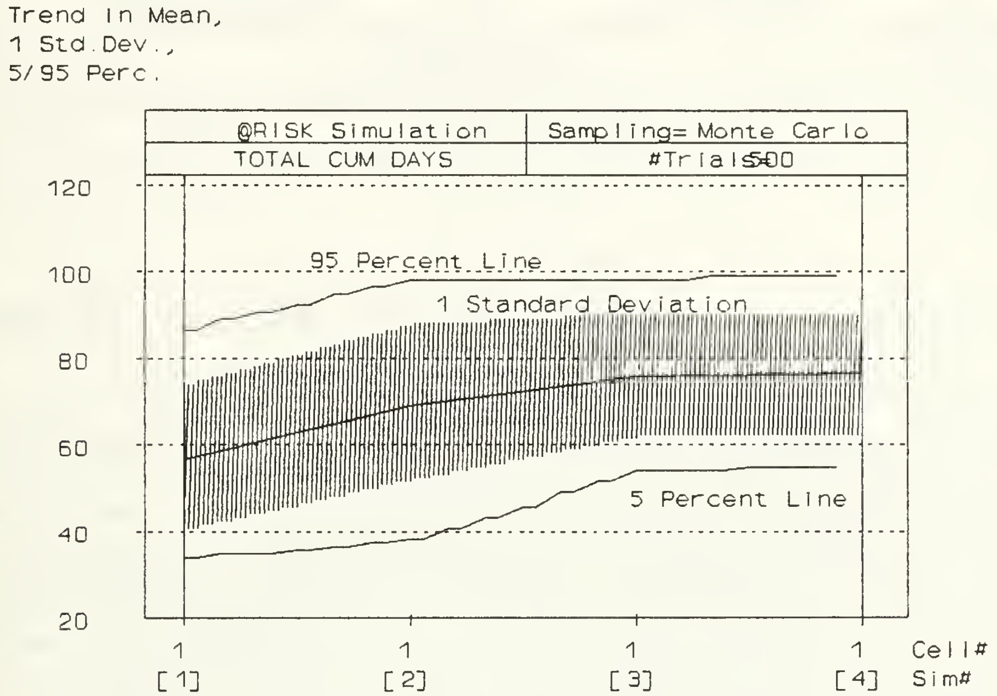


Figure 12
Trend Summary for Simulations 1 - 4

Figure 12 provides the inventory and material manager with a perspective of the modeled supply system delivery times. The variation between the four simulations does not appear significant. The standard deviation declined as the number of requisitions increased, which is consistent with the narrowing of the trend line in Figure 12. The standard deviation for requisitions processed increases with the number of

requisitions; however, the percentage of the deviation (against number submitted) remains approximately proportional throughout the DSS Strategy model simulation runs. The average number of days required for most material delivery is approximately 13. A review of the standard deviation for all simulations shows that requirements will be delivered between seven and 13 days of the average date (see Tables 6 through 9).

B. OVERVIEW OF THE DSS STRATEGY MODEL AT THE RETAIL, INTERMEDIATE, WHOLESALE, AND FACTORY LEVELS.

The objective of the DSS is to aid the inventory and material manager in reducing inventory levels. By adjusting the time when inventory begins to arrive at SUPSHIPNN, the inventory and material manager can influence the amount of possible inventory reduction. The retail level is the supply system's earliest contributor to inventory at SUPSHIPNN. Table 6 depicts the number of requisitions that the inventory or material manager can expect to be filled at the retail level. Further, the table shows the number of days that it will take the retail level to deliver the material.

TABLE 6 Retail Level Material and Delivery Schedule Data Source: Appendix B					
REQUISITION SIZE		AVERAGE NUMBER OF REQUISITIONS PROCESSED	STANDARD DEVIATION OF REQUISITIONS PROCESSED	AVERAGE MATERIAL DELIVERED (IN DAYS)	STANDARD DEVIATION OF DELIVERY DAYS
	150	126	6.404	13	6.281
	300	253	12.699	13	6.205
	750	631	32.309	14	6.238
	1500	1259	58.149	13	6.073

A review of the information in Table 6 shows that an average of 84 percent of the requisitions will be processed from the retail level. The average delivery time at retail level is approximately two weeks with a standard deviation of six days.

Table 7 depicts the DSS Strategy model results at the intermediate level.

TABLE 7 Intermediate Level Material and Delivery Schedule Data Source: Appendix B					
REQUISITION SIZE		AVERAGE NUMBER OF REQUISITIONS PROCESSED	STANDARD DEVIATION OF REQUISITIONS PROCESSED	AVERAGE MATERIAL DELIVERED (IN DAYS)	STANDARD DEVIATION OF DELIVERY DAYS
	150	20	5.557	15	5.761
	300	41	11.012	15	6.034
	750	102	28.535	15	5.589
	1500	206	50.836	15	5.739

When combined with the results of Table 6, the results of Table 7 show that 97 (i.e. 126+20/150) percent of the requisitions received from the retail level will be processed and delivered at the intermediate level within approximately four weeks.

Table 8 depicts the results of the DSS Strategy model at the wholesale level.

TABLE 8 Wholesale Level Material and Delivery Schedule Data Source: Appendix B					
REQUISITION SIZE		AVERAGE NUMBER OF REQUISITIONS PROCESSED	STANDARD DEVIATION OF REQUISITIONS PROCESSED	AVERAGE MATERIAL DELIVERED (IN DAYS)	STANDARD DEVIATION OF DELIVERY DAYS
	150	3	1.197	20	6.209
	300	6	2.470	20	6.527
	750	15	5.819	21	6.248
	1500	30	12.130	20	6.185

Of the remaining requisitions to be filled by the supply system (2 percent of the total requisitions submitted), an average additional delivery time of 20 days could be expected. The material delivery, for total material requested and satisfied thus far, will be in approximately six weeks.

Material that must be obtained from sources outside the supply system is depicted in Table 9.

TABLE 9 Factory Level Material and Delivery Schedule Data Source: Appendix B					
		AVERAGE NUMBER OF REQUISITIONS PROCESSED	STANDARD DEVIATION OF REQUISITIONS PROCESSED	AVERAGE MATERIAL DELIVERED (IN DAYS)	STANDARD DEVIATION OF DELIVERY DAYS
REQUISITION SIZE	150	0	0.460	8	13.417
	300	1	0.579	21	13.852
	750	2	1.181	27	9.237
	1500	4	2.363	28	8.579

The remaining requisitions (less than 1 percent) require an additional one to four weeks for processing and delivery to SUPSHIPNN.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS.

The purpose of this thesis is to develop a decision support model and strategy which would allow the inventory or material manager to reduce future investments in inventories. The change in the threats against the United States has influenced the political leaders of the United States to direct the DOD to reduce spending. As funds are reduced, targets of opportunity are shifting from the battlefield to the appropriation field. Dollars invested in inventories are a prime target of cost reduction. This study provides a model which will enable inventory managers at SUPSHIPNN to reduce inventories while meeting production target dates. Successful management of inventories is not a cost saving measure alone. The judicious use of valuable inventory and associated resources will maintain the fleet in the highest possible state of readiness.

To achieve this purpose four primary research questions were considered:

1. Can changes in inventory and material management reduce the size of inventories (specifically Q-COSAL) without affecting production schedules?

2. What elements contribute to inventory growth? What are the salient characteristics of these elements and how should they be expressed? Growth can be

expressed in physical size and cost. What are the ramifications of inventory growth?

3. What items are critical to production? Can non-critical material be accurately designated and how should it be managed?

4. What are the advantages of reducing inventories? What are the pitfalls?

To answer these questions a background literature study was conducted, reports from prior studies were analyzed, and telephone interviews with SUPSHIPNN personnel were conducted.

Inventory and material managers work in a dynamic environment. On one hand, production schedules and requirements may change; on the other hand, the variables such as inventory levels, transportation modes, and financial resources that are involved in procurement may change. To be successful, the strategy employed by the inventory and material personnel must consider the relevant variables and their effects on inventory growth. The thrust of the DSS Strategy model is to provide the inventory and material manager with a model that will enhance the decision process for material acquisition and reduce inventory growth. The goal of inventory management is to have the right amount of material, at the right place, at the right time. To have material arrive too early or too late will have some penalty. For material that arrives too early the penalties would likely include:

- Increased inventory holding costs.
- Increased risk of obsolescence.
- Greater susceptibility to loss or pilferage.
- Increased risk of unneeded inventory.

Material that arrives too late, especially in the shipbuilding environment would also result in penalties, such as:

- Delays in the production schedule. This penalty could be minor or very extreme in cost. The delay of a CVN could conceivably cost as much as the combined loss of the entire carrier group. This cost could include the cost of the CVN, its air wing, escort vessels, and support vessels.
- Increased expediting costs.

The DSS Strategy model presents alternative procurement lead times and probabilities of success in meeting target dates. Using situational input, the inventory or material manager can select an appropriate lead time that will match the production schedule and minimize inventory levels.

The following example demonstrates the alternatives presented by the use of the DSS:

> One of the key events in the new construction schedule is fast cruise. Fast cruise is performed by the ship's crew, late in the construction schedule. All of the ship's systems are operated and tested while the ship remains at the pier. Operational and repair parts must be on hand to support fast cruise testing. NAVSEA

directives mandate 100 percent of Q-COSAL material be on board prior to fast cruise. Suppose SUPSHIPNN material and inventory personnel have 119 days before fast cruise. They have the latest Q-COSAL changes and will begin processing them. The changes require the procurement of 150 requirements (Figure 13).

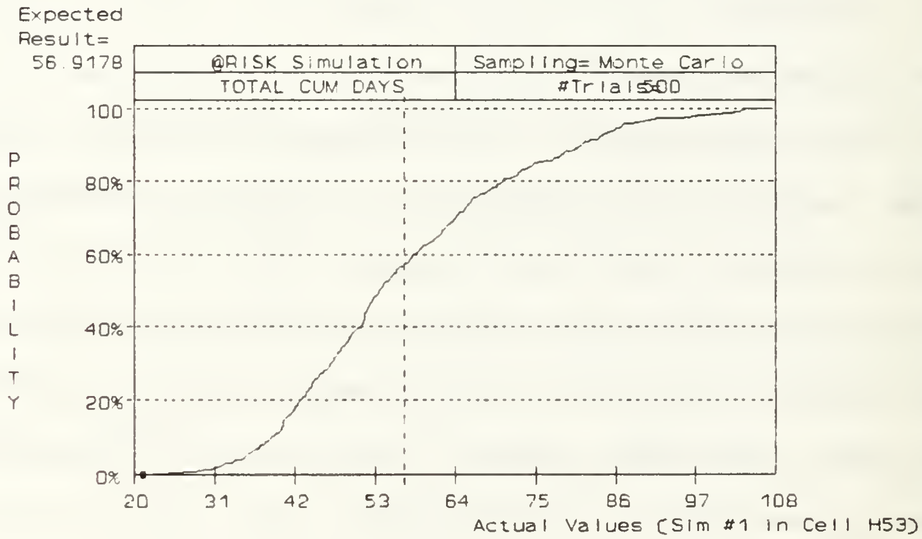


Figure 13
DSS Strategy Model Example

The DSS Strategy model is run with the above results. The model shows that with a 60 percent probability the material will arrive in 57 days. However, the current NAVSEA policy requires 100 percent of the material to be

on hand at fast cruise. If the manager could accept a 99 percent probability, he could delay ordering the material for two weeks and the material would be on hand for fast cruise (ordered 105 days prior to requirement).

The above example demonstrates a savings of two weeks inventory cost if the order was not placed immediately (ordered 119 days prior to requirement). If the items were shelf life sensitive, they would have a minimum of two additional weeks of use.

The above example also illustrates what may be the greatest temptation of the DSS. A manager may use the 100 percent probability as the default probability in all situations. The benefits of inventory reduction may not be readily apparent to the manager; therefore, he/she will focus only on the goal of having all material on hand. In many instances, the 100 percent probability will still result in reduced procurement lead time, thus reducing inventory levels. However, the advantage of using a realistic probability will yield greater benefits.

For example, if the manager is ordering material that is safety stock, a lower probability should be used. The selected probability should reflect the nature of the item and the potential impact on the production schedule. The benefits to the material manager are that expediting efforts can be

focused on material that is truly critical. The inventory manager will have less inventory on hand which will lower inventory cost and decrease the instances of shelf life expiration, loss, and obsolescence, all of which increase the inventory work load.

Using the above example, the manager may also want to know how each level of the supply system will respond to the 150 requisitions. The DSS Strategy model provides the information for each level of the system, thus allowing a manager to see when inventory will begin to accumulate and from what source (Figures 14 and 15).

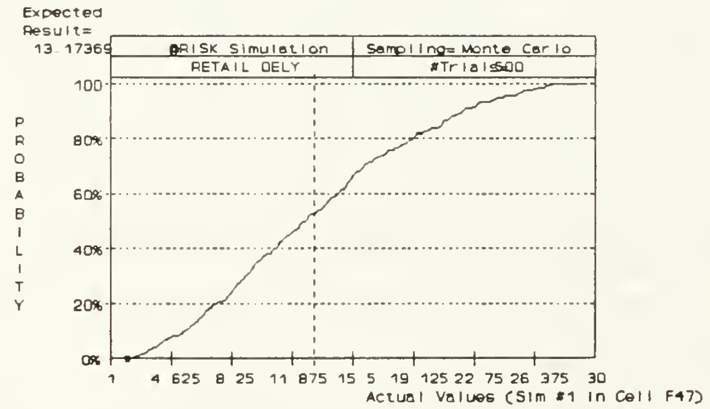


Figure 14
Retail Level Delivery

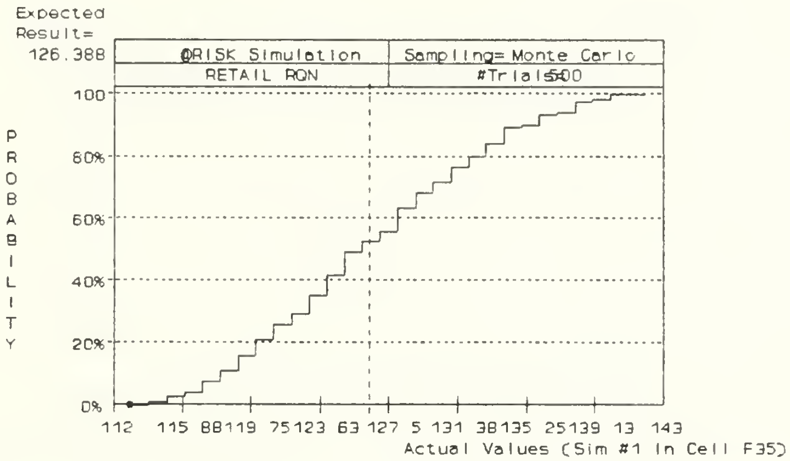


Figure 15
Retail Level Requisitions Processed

Figures 14 and 15 show the manager that inventory will begin to accumulate approximately two days after the requisitions are submitted to the supply system. The inventory will be received within 19 days. The inventory manager can now delay the arrival of the 129 items by approximately 100 days (refer to Figure 13). To delay the material, a low requisition priority combined with a required delivery date very near fast cruise will result in available items being shipped via the slowest transportation method. The material manager can plan the anticipated expediting actions for the remaining 21 items.

To plan expediting, a view of the remaining supply levels are provided by the DSS (Figures 16, 17, 18, 19, 20, and 21).

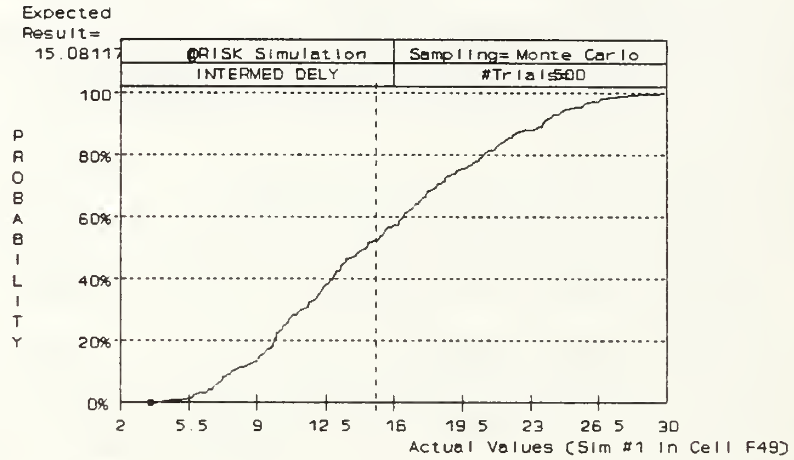


Figure 16
Intermediate Level Delivery

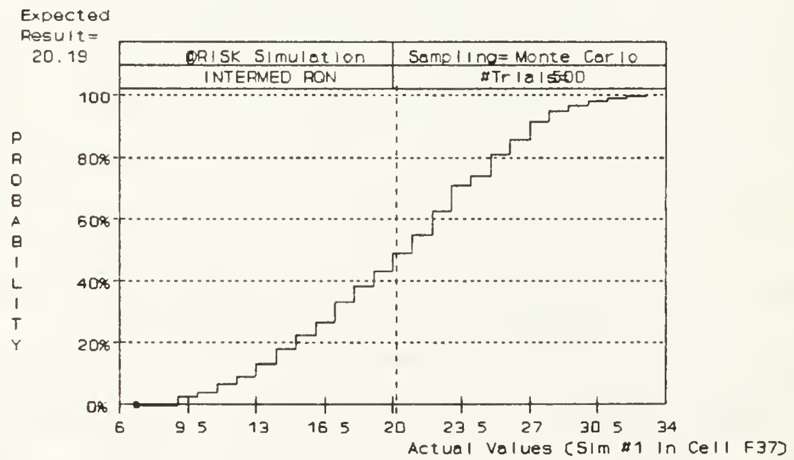


Figure 17
Intermediate Level Requisitions Processed

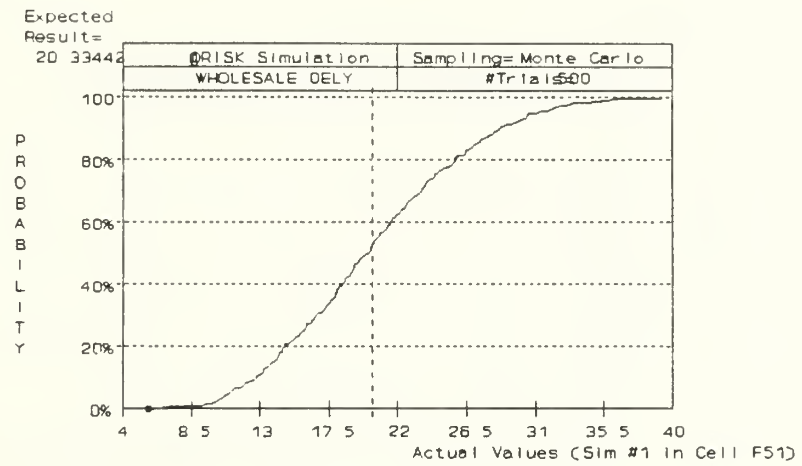


Figure 18
Wholesale Level Delivery

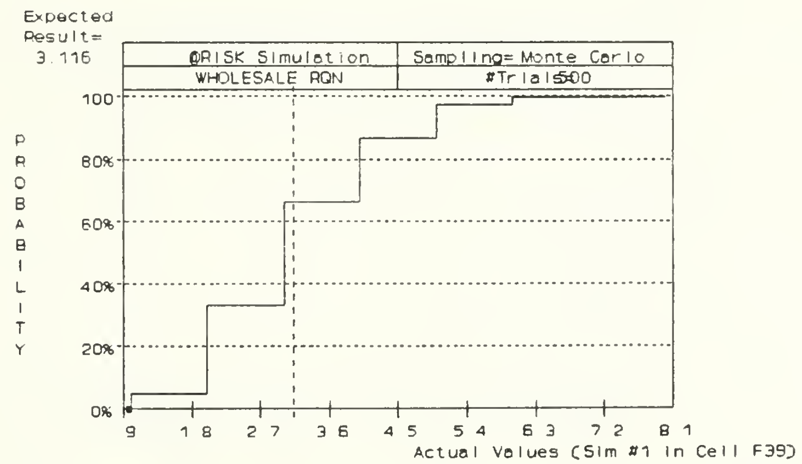


Figure 19
Wholesale Level Requisitions Processed

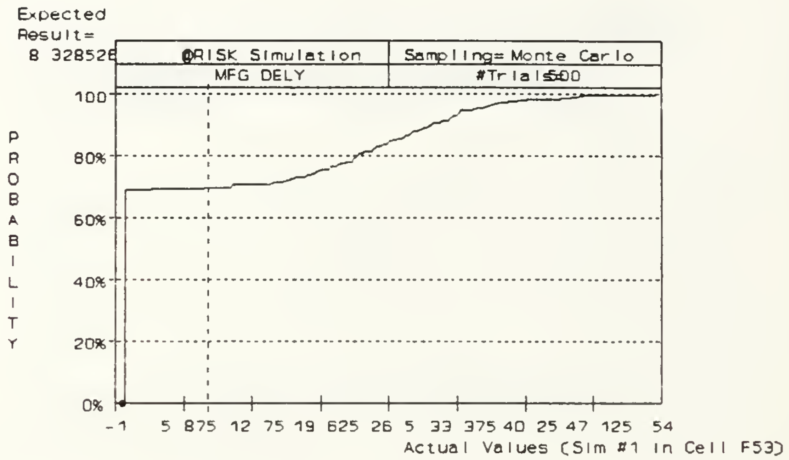


Figure 20
Manufacturer Delivery

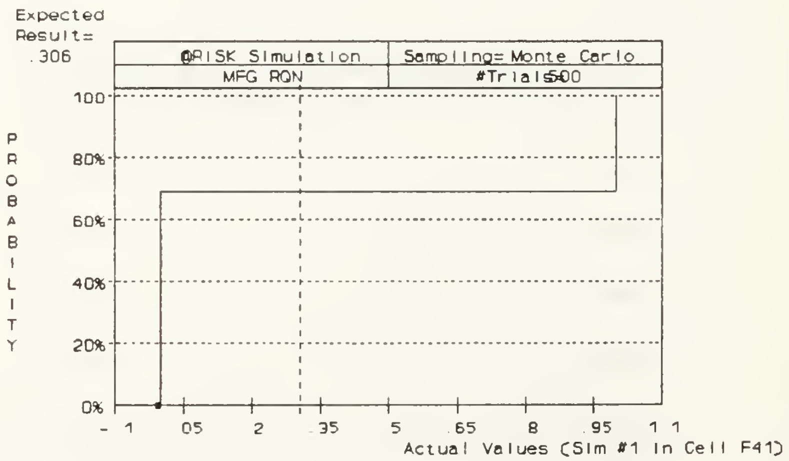


Figure 21
Manufacturer Requisitions Processed

The material manager may conclude that since the majority of the remaining 21 requisitions will be processed at the intermediate level and delivered in an average of 34 days (19+15 = 34), he/she will likely need to expedite only three or four items. The material manager now has a picture of the requirements and the probability of where and when they will be filled. The inventory manager can plan receipt processing since expected delivery times and material volume are available.

Thus far, it has been shown that the DSS can reduce inventory levels and holding costs. What is the impact of the DSS Strategy model on obsolescence and changing requirements? Continuing with the above example, a requisition of Q-COSAL chemicals (specific nomenclature and use has been avoided to keep the study unclassified) with a quantity of 1500 quarts is required (from the original example of 150) at a unit cost of $123.00 each (total cost $186,500.00). Suppose that the chemical has a shelf life of 90 days and has been in inventory at the NSC for 30 days. To prevent a vessel from receiving chemicals that are or soon will be expired, NSC normally will not ship this chemical with less than 20 days remaining shelf life. If the chemical is ordered 17 weeks prior to fast cruise, the chemical will need to be replaced at least once prior to fast cruise. At a minimum, this loss to obsolescence would be $186,500.00. By using the DSS Strategy model, the

chemical received should have a shelf life of approximately 40 days. This is assumption is based on the premise that the chemical will be replenished at NSC starting on day 49. The DSS Strategy model shows the inventory manager he/she can wait until 27 days prior to the scheduled date (Figure 14 using a 100 percent probability). If the requirement had changed (to another chemical), the window for canceling unwanted material would be approximately 18 days without the DSS Strategy model and approximately 105 days with the DSS Strategy model. The DSS Strategy model provides the material and inventory manager with opportunities to control inventory growth, minimize obsolescence, and reduce unwanted inventory.

To illustrate the potential annual savings by use of the DSS, Table 9 depicts an example of CVN inventory reduction.

TABLE 9
POTENTIAL TOTAL INVENTORY
ANNUAL SAVINGS

PERCENT OF REDUCTION	CVN INVENTORY	ANNUAL INVENTORY COST*	SAVINGS
0%	44,000,000	9,944,000	N/A
1%	44,000,000	9,844,560	99,440
2%	44,000,000	9,745,120	198,880
3%	44,000,000	9,645,680	298,320
10%	44,000,000	8,949,600	994,400
15%	44,000,000	8,452,400	1,491,600
20%	44,000,000	7,955,200	1,988,800

* Of $44 million inventory, 20 percent are consumables which

have an annual holding cost of $.21 (per dollar expended), 80 percent are repair parts which have an annual holding cost of $.23 (per dollar expended).

The DSS Strategy model is not a black box approach to inventory reduction. The inputs affecting the parameters are provided by personnel who are familiar with the behavior of the parameters and have access to the data which affect the parameters. The model allows the inventory or material manager to adjust the scenario to fit the dynamic environment of shipbuilding. Thus, as inventory levels, transportation modes, and production schedules change, the manager can adjust the model parameters and obtain realistic results. The result (an expected value) is not an end unto itself. The judgement and experience of the manager must be used to evaluate the result within the shipbuilding environment and make an informed decision.

B. RECOMMENDATIONS

The motivation for personnel to utilize decision tools hinges on the benefits and pitfalls that individuals will encounter by using them. If the tool does little to provide a benefit to the user, it will not likely be used even if the organization would benefit from its use. The material and inventory manager must be given some incentive to reduce inventories. Presently, the incentive which is paramount in the author's view is that all material required for

production, testing, or ship delivery must be on hand. To ensure it is on hand, material and inventory personnel will order and store the material as soon as funding permits. With the exception of shelf life chemicals, no consideration is given to adjusting delivery times to match production schedules.

The lack of lead time management is not unique to the shipbuilding environment. According to Perry [Ref.18:p.6], DOD managers experience longer and more variable procurement lead times than well-managed private sector firms who compete in non-DOD markets. Perry notes in his study: [Ref.18:p.7]

> For every $100 invested by the airline in safety level inventory, the DOD invests about $214 for the same item, based strictly on procurement lead time alone.
>
> As DOD lead times increase, inventory managers often seek to compensate by increasing the investment in safety levels and to reduce workload by increasing order quantities for inventory replenishment. However, with increasing lead times, the risks of higher safety levels and larger order quantities are more substantial because demand forecasting is typically less accurate. Accumulation of unneeded inventories is the inevitable result.

The SUPSHIPNN inventory and material managers find themselves in a "catch 22" position. They face considerable pressure to have all material on hand prior to the actual requirement (as a safety measure). However, the material requirements may change, production schedules may slip, or the material may become obsolete.

In the preceding sections, the issue of criticality has

been addressed. The present requirement for 100 percent of Q-COSAL material to be on board at fast cruise, by implication, means every piece of material is critical to the new construction process. In the fleet, the requirement is that 100 percent of Q-COSAL material be on hand or on order at all times.

By changing the requirement to meet fleet standards (100 percent on hand or on order), material and inventory management personnel could take advantage of the DSS Strategy model and would benefit from a reduced workload and lower inventory levels. The reduction in work would be obtained from less reordering due to changing requirements, loss, and obsolescence, and from decreased expediting. Inventory managers will have less inventory to process and less unneeded inventory to return to the supply system or disposal.

Incentives and penalties matter. The performance of material and inventory personnel are not based on inventory reduction within production targets. The incentive is to avoid a production delay. Material and inventory personnel do not necessarily view inventory growth or its consequences as their problem. Inventory growth will not, in their opinion, affect their jobs. Not meeting a production schedule is another issue altogether. They feel that a delay would be attributed to them and would jeopardize their positions, and ultimately their jobs.

The ILSMT and the close interaction with production personnel is an excellent method for determining what material will impact production. The knowledge of what constitutes a requirement that would cause the greatest penalty (delay in production) gives material managers the freedom to actively manage procurement actions. Production information reduces the uncertainty regarding anticipated demand. In essence, the area of uncertainty is focused on only those items which contribute to the production goals. Once the material manager's environment is limited to truly critical material, the fear of not having all material (most of which may not be critical) will be removed from the work place.

Incentives can be used to aggressively manage inventory growth. Obsolescence rates, loss rates, and minimum holding time can be incorporated as measures of effectiveness for material and inventory management personnel. When incentives are correctly applied and penalties for uncontrollable events are removed, personnel will utilize the tools that can afford the greatest benefits to the organization. Otherwise, people will tend to take actions that will secure their positions or mitigate personal liability, regardless of the cost or loss of benefit to the organization.

As previously stated, the shipbuilding environment is dynamic in nature and inventory and material personnel must have the flexibility to operate within this environment.

Shipbuilding contracts require the use of government furnished equipment (GFE) and government furnished material (GFM) where practical and possible. The arrival of this material must coincide with production schedules. Problems occur when production schedules or design changes cause material requirements to change, either in delivery dates, quantities, or nomenclature. The most feared consequence (from the Navy viewpoint) is a delay claim by the contractor against the Navy. A delay claim can occur when material is late or on hand material does not meet quality standards. One goal of SUPSHIPNN and the Navy should be to mitigate the circumstances whereby a shipbuilder can make a claim against the Navy. For example, future contracts should use realistic "delivery windows" for GFE and GFM instead of delivery dates assigned early in the production schedule. A delivery schedule, developed and implemented early on, may not reflect reality later in production. Procedures should be established that would allow SUPSHIPNN production personnel to authorize adjustments to the production critical path. These procedures would allow rescheduling of work which is awaiting GFM or GFE.

The above recommendations do not imply that material should be allowed to be late, but it recognizes that because of the shipbuilding environment, some material may be late.

The DSS Strategy model allows the material and inventory

personnel to manage procurement and inventory in this environment. The model can be adjusted (by changing the parameters) to model the requirements as they change. The results of the model can be analyzed by the production and material personnel to plan a course of action that will reduce the adverse affects of a requirement change. This recommendation hinges on the development of a formal method (such as a procedure) that integrates the functions of production control, material, and inventory management. To work, the system must promote maximum communication, close coordination, and clear understanding between the entities.

The Defense Management Review Directives (DMRD) will change the Navy and DOD supply system in two major ways. First, the stock points are to be consolidated. The present nomenclature of inventories will change. The distinction between retail, intermediate, and wholesale inventories will fade. Organizations and inventories will be consolidated and managed under a unified system. Second, consumable items are migrating to the Defense Logistics Agency (DLA) for management. Consolidation means that fewer and fewer consumable items will be managed by one or more services. The DSS Strategy model, using LOTUS 123 with the @RISK add on, has the flexibility to adjust to the changing supply system environment. The LOTUS 123 spreadsheet can be adjusted to add or delete changing supply functions, and the distributions

affecting the new environment can be entered. The material and inventory manager will require a large degree of flexibility to correctly model not only the DMRD changes, but the continual changes in stock availability, transportation times, and funding constraints that contribute to the variable aspects of procurement.

By modeling the variability of the supply system, and obtaining the best probability or chance of a given outcome, the material and inventory manager can reduce inventory levels. The benefits of inventory reduction include:

- Increased forecasting accuracy. The further away from the required date that a forecast is made, the less accurate that forecast will be. Requirements may change because of design instability or technological improvements.

- Greater flexibility in order quantity and size. Given the dynamic nature of the shipbuilding environment, a shorter planning horizon will increase the ability of the inventory and material manager to adjust quantities and size.

- Lower inventory holding costs. The closer the timing of the requirement to the production schedule, the less time the requirement will spend in inventory. The associated costs that will be reduced are inventory loss, obsolescence, disposal, and turn-in.

- Limited requirement for mock-up facilities. Recent improvements in identifying size, weight, and special storage considerations may make the use of a mock-up obsolete. Programs such as HAYSTACK and Technical Logistical Reference Library (TLRN) provide inventory personnel with the necessary tools to plan on board storage without the use of expensive mock-up facilities. The DSS compliments the concept of limited or zero mock-up facilities.

- Reduced opportunity costs. The practice of obtaining and

holding requirements in inventory in the shipyard removes those items from fleet use. This increases the opportunity cost to the fleet for items held (especially for long periods of time) in shipyard inventories. The DSS allows for items to remain in the supply system inventory for as long as practical. By not holding inventory at the shipyard, the fleet will benefit from increased stock availability from the supply system.

To be successful, the DSS must involve the commitment of both production and material personnel. Through their joint action, substantive improvements in inventory reduction can be accomplished with the DSS.

C. FURTHER RESEARCH.

Further research is required in the applicability of new models for the determination of shipyard inventory levels. The models should focus on the use of the DOD supply system as the primary source for material and as the primary source for backup or safety level material. Research should study the appropriate levels of inventories that are required by NAVSEA and other higher authorities. Material criticality and its affect on production schedules should be examined. The implementation of realistic methods for determining and evaluating critical requirements, are required.

Additional study will be required to determine appropriate costs for penalties. In this endeavor, the study should investigate the affect of unit costing by SUPSHIPs (in Navy or private shipyards) to variations in inventory levels. A detailed study in the area of costs and penalties could lead

to specific corrective actions in reducing shipyard inventories.

Once the recommendations of this and other studies are implemented, follow-on studies should be conducted to determine the effectiveness of these methods. Improvements and corrective actions should identify target areas that will benefit from their implementation based on existing conditions.

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APPENDIX A

DSS STRATEGY MODEL SPREADSHEED CODE

```
A3: 'TOTAL NUMBER OF REQUISITIONS:
F3: @SIMTABLE(150,300,750,1500,4)
A5: 'PROBABILITY (IN PERCENT) OF
F5: ^MOST
A6: 'REQUESITION BEING FILLED AT:
E6: ^WORST
F6: ^LIKELY
G6: ^BEST
B8: 'RETAIL LEVEL:
E8: 0.75
F8: 0.82
G8: 0.95
B9: 'INTERMEDIATE LEVEL:
E9: 0.75
F9: 0.87
G9: 0.95
B10: 'WHOLESALE LEVEL:
E10: 0.75
F10: 0.93
G10: 0.95
B11: 'FACTORY:
E11: 0.97
F11: 0.99
G11: 1
A13: 'BEST, MOST LIKELY, WORST
F13: ^MOST
A14: 'PROCESSING TIMES AT:
E14: ^BEST
F14: ^LIKELY
G14: ^WORST
B16: 'RETAIL LEVEL:
E16: 0.0416
F16: 0.5
G16: 1
B17: 'INTERMEDIATE LEVEL:
E17: 0.0416
F17: 0.5
G17: 1
B18: 'WHOLESALE LEVEL:
E18: 0.0416
F18: 3
```

```
G18: 14
B19: 'FACTORY:
E19: 0.0416
F19: 7
G19: 30
A23: 'BEST, WORST, MOST LIKELY
F23: ^MOST
A24: 'DELIVERY TIMES (IN DAYS) FROM:
E24: ^BEST
F24: ^LIKELY
G24: ^WORST
B26: 'RETAIL LEVEL:
E26: 1
F26: 7
G26: 30
B27: 'INTERMEDIATE LEVEL:
E27: 3
F27: 10
G27: 30
B28: 'WHOLESALE LEVEL:
E28: 3
F28: 11
G28: 30
B29: 'FACTORY:
E29: 3
F29: 14
G29: 30
A33: 'SIMULATION RESULTS (QUICK LOOK)
A35: 'NUMBER FILLED AT RETAIL LEVEL:
F35: (F0) @ROUND(@TRIANG(E8,F8,G8)*(F3),0)
A37: 'NUMBER FILLED AT INTERMEDIATE LEVEL:
F37: (F0) @ROUND(@TRIANG(E9,F9,G9)*(F3-F35),0)
A39: 'NUMBER FILLED WHOLESALE LEVEL:
F39: (F0) @ROUND(@TRIANG(E10,F10,G10)*(F3-(F35+F37)),0)
A41: 'NUMBER FILLED BY MANUFACTURER:
F41: (F0)
@ROUND(@TRIANG(E11,F11,G11)*(F3-(F35+F37+F39)),0)
A44: 'INVENTORY POSITION:
F44: ^DAYS
G44: '        CUMULATIVE
H45: ^DAYS
A47: 'DELIVERY FROM COMSUMER LEVEL:
E47: (H) @IF(F35<1,0,1)
F47: (F0) +E47*@TRIANG(E26,F26,G26)+@TRIANG(E16,F16,G16)
H47: (F0) +F47
A49: 'DELIVERY FROM INTERMEDIATE LEVEL:
E49: (H) @IF(F37<1,0,1)
F49: (F0) +E49*@TRIANG(E27,F27,G27)+@TRIANG(E17,F17,G17)
H49: (F0) +H47+F49
```

```
A51: 'DELIVERY FROM WHOLESALE LEVEL:
E51: (H) @IF(F39<1,0,1)
F51: (F0) +E51*@TRIANG(E28,F28,G28)+@TRIANG(E18,F18,G18)
H51: (F0) +H49+F51
A53: 'DELIVERY FROM MANUFACTURER:
E53: (H) @IF(F41<1,0,1)
F53: (F0) +E53*(@TRIANG(E29,F29,G29)+@TRIANG(E19,F19,G19))
H53: (F0) +H51+F53
```

APPENDIX B

DSS STRATEGY MODEL SIMULATION REPORTS

INTERMED DELY (Sim #1 in Cell F49)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = 15.08117
Maximum Result = 29.64979
Minimum Result = 3.69378
Range of Possible Results = 25.95601
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 5.761916
Skewness = .3018955
Kurtosis = 2.246147
Variance = 33.19968
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500
Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 3.6938 = 0%
<= 6.7135 = 5%
<= 7.5995 = 10%
<= 9.0711 = 15%
<= 9.8071 = 20%
<= 10.3105= 25%
<= 11.2217= 30%
<= 12.0953= 35%
<= 12.735 = 40%
<= 13.3324= 45%
<= 14.4865= 50%
<= 15.461 = 55%
<= 16.4727= 60%
<= 17.2868= 65%
<= 18.1937= 70%
<= 19.2121= 75%
<= 20.5629= 80%
<= 21.776 = 85%
<= 23.6233= 90%
<= 24.8782= 95%
<= 29.6498=100%

Probabilities for Selected Values:
========================

Probability of Result
> 0 = 100%
>=3 = 100%
>=6 = 97%
>=9 = 85.8%
>=12 = 65.8%
>=15 = 47.8%
>=18 = 31.2%
>=21 = 18.4%
>=24 = 8%
>=27 = 1.6%
>=30 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================
@HISTOGRM(3.69378,29.64979,.014348,.024055,.061145,.039247,.100266,.0697,.093856,.082382,.057379,.077088,.069306,.061227,.05,.054596,.030307,.050097,.0293,.0207,.007795,.007205,20)

INTERMED DELY (Sim #2 in Cell F49)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 15.06637
Maximum Result = 29.43597
Minimum Result = 4.212346
Range of Possible Results = 25.22362
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.034641
Skewness = .3624705
Kurtosis = 2.145303
Variance = 36.41689
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 4.2123	= 0%
<= 6.5084	= 5%
<= 7.5642	= 10%
<= 8.6085	= 15%
<= 9.7052	= 20%
<= 10.2233	= 25%
<= 10.9635	= 30%
<= 11.7566	= 35%
<= 12.45	= 40%
<= 13.1821	= 45%
<= 13.9304	= 50%
<= 14.7671	= 55%
<= 15.6856	= 60%
<= 17.0508	= 65%
<= 18.6177	= 70%
<= 20.0175	= 75%
<= 21.1915	= 80%
<= 22.6817	= 85%
<= 23.6892	= 90%
<= 25.8933	= 95%
<= 29.436	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=3	= 100%
>=6	= 96.2%
>=9	= 83.2%
>=12	= 63.2%
>=15	= 43.8%
>=18	= 32.6%
>=21	= 20.8%
>=24	= 9%
>=27	= 2.8%
>=30	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(4.212346,29.43597,.024757,.033973,.05627,.06265,.09235,.083584,.091416,.077447,.06249,.05474,.038793,.051397,.04905,.039958,.063205,.041187,.021385,.028624,.019209,7.51555E-03,20)

INTERMED DELY (Sim #3 in Cell F49)
@RISK Risk Analysis
22-Oct-1991
=========================

Expected/Mean Result = 14.70067
Maximum Result = 29.52006
Minimum Result = 4.095975
Range of Possible Results = 25.42409
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 5.589228
Skewness = .4841405
Kurtosis = 2.48157
Variance = 31.23947
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
=========================

```
<= 4.096   = 0%
<= 6.6267  = 5%
<= 8.1731  = 10%
<= 9.0488  = 15%
<= 9.5303  = 20%
<= 10.1433= 25%
<= 10.9322= 30%
<= 11.6064= 35%
<= 12.205  = 40%
<= 12.9523= 45%
<= 13.8272= 50%
<= 14.4833= 55%
<= 15.7239= 60%
<= 16.5566= 65%
<= 17.6516= 70%
<= 18.606  = 75%
<= 19.5207= 80%
<= 21.155  = 85%
<= 22.931  = 90%
<= 24.9037= 95%
<= 29.5201= 100%
```

Probabilities for Selected Values:
=========================

```
Probability of Result
    > 0       = 100%
    >=3       = 100%
    >=6       = 97.2%
    >=9       = 85.2%
    >=12      = 61.6%
    >=15      = 43.4%
    >=18      = 28.6%
    >=21      = 15.4%
    >=24      = 7.8%
    >=27      = 2.6%
    >=30      = 0%
Probability of Result
    <= 0      = 0%
```

@Function For This Output Distribution:
=========================

@HISTOGRM(4.095975,29.52006,.015,.035,.034171,.073977,.109584,.097267,.088695,.086305,.053998,.066002,.05916,.074798,.034715,.046326,.032515,.03024,.032245,.005,.014119,.010881,20)

INTERMED DELY (Sim #4 in Cell F49)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 14.90956
Maximum Result = 29.82361
Minimum Result = 4.003199
Range of Possible Results = 25.82041
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 5.739444
Skewness = .4408553
Kurtosis = 2.401724
Variance = 32.94122
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 4.0032 = 0%
<= 6.6436 = 5%
<= 7.7705 = 10%
<= 8.7952 = 15%
<= 9.6207 = 20%
<= 10.2836= 25%
<= 10.9544= 30%
<= 11.6305= 35%
<= 12.571 = 40%
<= 13.1785= 45%
<= 13.9978= 50%
<= 15.0602= 55%
<= 16.0112= 60%
<= 16.9404= 65%
<= 17.9044= 70%
<= 18.6431= 75%
<= 19.9455= 80%
<= 21.3451= 85%
<= 23.3353= 90%
<= 25.657 = 95%
<= 29.8236= 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=3 = 100%
>=6 = 98.4%
>=9 = 84%
>=12 = 63.8%
>=15 = 45.4%
>=18 = 29.6%
>=21 = 17%
>=24 = 8.2%
>=27 = 2.4%
>=30 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(4.003199,29.82361,.01,.038307,.054965,.071727,.082823,.097177,.084885,.077625,.065762,.065509,.060374,.075679,.043351,.036815,.03795,.02205,.035,.019567,.013699,.006734,20)

INTERMED RQN (Sim #1 in Cell F37)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 20.19
Maximum Result = 33
Minimum Result = 7
Range of Possible Results = 26
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 5.557148
Skewness = -.1345077
Kurtosis = 2.252364
Variance = 30.88189
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 7	= 0%
<= 10	= 5%
<= 13	= 10%
<= 14	= 15%
<= 15	= 20%
<= 16	= 25%
<= 17	= 30%
<= 18	= 35%
<= 19	= 40%
<= 20	= 45%
<= 21	= 50%
<= 21	= 55%
<= 22	= 60%
<= 23	= 65%
<= 23	= 70%
<= 25	= 75%
<= 25	= 80%
<= 26	= 85%
<= 27	= 90%
<= 29	= 95%
<= 33	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=4	= 100%
>=8	= 99.8%
>=12	= 92.6%
>=16	= 77.6%
>=20	= 56.6%
>=24	= 29%
>=28	= 8.6%
>=32	= .8%
>=36	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(7,33,.005,.025,.02,.045,.04,.055,.08,.065,.05,.05,.115,.08,.08,.095,.055,.055,.05,.015,9.99999E-03,.01,20)

INTERMED RQN (Sim #2 in Cell F37)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = 40.714
Maximum Result = 67
Minimum Result = 14
Range of Possible Results = 53
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 11.01218
Skewness = -.2368066
Kurtosis = 2.411481
Variance = 121.2682
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 14	= 0%
<= 21	= 5%
<= 25	= 10%
<= 28	= 15%
<= 31	= 20%
<= 33	= 25%
<= 35	= 30%
<= 36	= 35%
<= 38	= 40%
<= 40	= 45%
<= 42	= 50%
<= 43	= 55%
<= 44	= 60%
<= 46	= 65%
<= 48	= 70%
<= 49	= 75%
<= 51	= 80%
<= 52	= 85%
<= 54	= 90%
<= 58	= 95%
<= 67	=100%

Probabilities for Selected Values:
===========================

Probability of Result

> 0	= 100%
>=7	= 100%
>=14	= 100%
>=21	= 96%
>=28	= 85.4%
>=35	= 71.8%
>=42	= 51%
>=49	= 26.8%
>=56	= 7.6%
>=63	= 1%
>=70	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
===========================

@HISTOGRM(14,67,.01,.02,.03,.03,.055,.035,.065,.065,.065,.085,.105,.07,.095,.105,.05,.055,.035,.015,.005,.005,20)

INTERMED RQN (Sim #3 in Cell F37)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 101.916
Maximum Result = 167
Minimum Result = 34
Range of Possible Results = 133
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 28.54513
Skewness = -.1607593
Kurtosis = 2.348415
Variance = 814.8246
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 34	= 0%
<= 52	= 5%
<= 62	= 10%
<= 70	= 15%
<= 77	= 20%
<= 80	= 25%
<= 85	= 30%
<= 90	= 35%
<= 95	= 40%
<= 99	= 45%
<= 103	= 50%
<= 108	= 55%
<= 112	= 60%
<= 115	= 65%
<= 118	= 70%
<= 123	= 75%
<= 128	= 80%
<= 133	= 85%
<= 139	= 90%
<= 147	= 95%
<= 167	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=20	= 100%
>=40	= 98.8%
>=60	= 92.2%
>=80	= 76.2%
>=100	= 54.8%
>=120	= 28%
>=140	= 9.8%
>=160	= .6%
>=180	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(34,167,.015,.015,.02975,.02825,.042,.04725,.0755,.06225,.07425,.06825,.0825,.084,.10325,.06775,.06375,.04625,.05,.025,.015,.005,20)

INTERMED RQN (Sim #4 in Cell F37)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 206.42
Maximum Result = 319
Minimum Result = 76
Range of Possible Results = 243
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 50.83621
Skewness = -.2173211
Kurtosis = 2.613354
Variance = 2584.321
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 76	= 0%
<= 115	= 5%
<= 133	= 10%
<= 149	= 15%
<= 162	= 20%
<= 172	= 25%
<= 181	= 30%
<= 189	= 35%
<= 196	= 40%
<= 203	= 45%
<= 211	= 50%
<= 218	= 55%
<= 225	= 60%
<= 229	= 65%
<= 235	= 70%
<= 240	= 75%
<= 249	= 80%
<= 258	= 85%
<= 268	= 90%
<= 286	= 95%
<= 319	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=40	= 100%
>=80	= 99.8%
>=120	= 94%
>=160	= 81.6%
>=200	= 57.8%
>=240	= 25.8%
>=280	= 6.8%
>=320	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(76,319,.00915,.01585,.019083,.029917,.033188,.042562,.04525,.06,.07,.08375,.080375,.089875,.11075,.09525,.07,.05,.038875,.021125,.01475,.02025,20)

MFG DELY (Sim #1 in Cell F53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 8.328526
Maximum Result = 53.31016
Minimum Result = 0
Range of Possible Results = 53.31016
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 13.41779
Skewness = 1.249617
Kurtosis = 3.13407
Variance = 180.0372
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 0	= 0%
<= 0	= 5%
<= 0	= 10%
<= 0	= 15%
<= 0	= 20%
<= 0	= 25%
<= 0	= 30%
<= 0	= 35%
<= 0	= 40%
<= 0	= 45%
<= 0	= 50%
<= 0	= 55%
<= 0	= 60%
<= 0	= 65%
<= 10.5034	= 70%
<= 19.2407	= 75%
<= 23.2368	= 80%
<= 26.5925	= 85%
<= 30.5421	= 90%
<= 34.8549	= 95%
<= 53.3102	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=6	= 30.4%
>=12	= 29.6%
>=18	= 26.6%
>=24	= 18.6%
>=30	= 11.2%
>=36	= 4%
>=42	= 2%
>=48	= .6%
>=54	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(0,53.31016,.695,.002538,0,.004335,.005386,.011472,.025,.03,.04,.035,.035,.03,.034058,.018418,.010928,.005084,.006345,.005168,3.06958E-03,0,20)

MFG DELY (Sim #2 in Cell F53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 20.80126
Maximum Result = 50.49367
Minimum Result = 0
Range of Possible Results = 50.49367
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 13.85236
Skewness = -.3405116
Kurtosis = 1.974128
Variance = 191.8878
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 0	= 0%
<= 0	= 5%
<= 0	= 10%
<= 0	= 15%
<= 0	= 20%
<= 9.6239	= 25%
<= 15.0117	= 30%
<= 18.095	= 35%
<= 21.282	= 40%
<= 22.8004	= 45%
<= 23.8405	= 50%
<= 25.105	= 55%
<= 26.7244	= 60%
<= 27.8684	= 65%
<= 29.6847	= 70%
<= 30.6537	= 75%
<= 32.2088	= 80%
<= 34.6615	= 85%
<= 36.8421	= 90%
<= 40.6635	= 95%
<= 50.4937	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=6	= 75.2%
>=12	= 73.8%
>=18	= 65.6%
>=24	= 49.4%
>=30	= 28%
>=36	= 12.2%
>=42	= 3.6%
>=48	= .4%
>=54	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(0,50.49367,.245,.002623,0,.003363,.016099,.034695,.035303,.036605,.073292,.106283,.090425,.092429,.082571,.05,.05,.025,.028281,.014344,.007376,.005,20)

MFG DELY (Sim #3 in Cell F53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 27.151
Maximum Result = 51.9077
Minimum Result = 0
Range of Possible Results = 51.9077
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 9.237238
Skewness = -.2370351
Kurtosis = 3.464396
Variance = 85.32656
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 0	= 0%
<= 12.8002	= 5%
<= 15.6431	= 10%
<= 17.7695	= 15%
<= 19.637	= 20%
<= 21.204	= 25%
<= 22.3729	= 30%
<= 23.8528	= 35%
<= 25.0914	= 40%
<= 26.2624	= 45%
<= 27.405	= 50%
<= 28.6621	= 55%
<= 29.5319	= 60%
<= 30.8094	= 65%
<= 31.9201	= 70%
<= 33.2363	= 75%
<= 34.8662	= 80%
<= 36.2382	= 85%
<= 38.0404	= 90%
<= 42.1446	= 95%
<= 51.9077	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=6	= 97.8%
>=12	= 96.2%
>=18	= 84.4%
>=24	= 64.4%
>=30	= 38.2%
>=36	= 15.4%
>=42	= 5.4%
>=48	= 1.2%
>=54	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(0,51.9077,.02,.002538,0,0,.025,.048502,.066498,.07,.105,.098191,.109426,.117383,.11,.08,.054811,.035189,.02,.017576,.012424,.005,20)

MFG DELY (Sim #4 in Cell F53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 27.95277
Maximum Result = 53.3605
Minimum Result = 6.586362
Range of Possible Results = 46.77414
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 8.579347
Skewness = .2159143
Kurtosis = 2.943105
Variance = 73.60519
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 6.5864	= 0%
<= 13.9128	= 5%
<= 17.1766	= 10%
<= 18.9975	= 15%
<= 20.8482	= 20%
<= 21.8081	= 25%
<= 23.0266	= 30%
<= 24.1134	= 35%
<= 25.5213	= 40%
<= 26.8624	= 45%
<= 28.0499	= 50%
<= 29.0717	= 55%
<= 29.8135	= 60%
<= 30.8963	= 65%
<= 32.1466	= 70%
<= 33.6037	= 75%
<= 34.7681	= 80%
<= 36.5342	= 85%
<= 39.1401	= 90%
<= 42.401	= 95%
<= 53.3605	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=6	= 100%
>=12	= 97%
>=18	= 88.8%
>=24	= 65.8%
>=30	= 39.2%
>=36	= 16.6%
>=42	= 5.2%
>=48	= 2%
>=54	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(6.586362,53.3605,.007865,.016409,.024215,.026511,.053487,.066027,.104562,.085924,.104414,.11807,.10116,.089041,.062314,.045,.037009,.022991,9.99999E-03,.009843,.009805,.005353,20)

MFG RQN (Sim #1 in Cell F41)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = .306
Maximum Result = 1
Minimum Result = 0
Range of Possible Results = 1
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = .4608294
Skewness = .8419634
Kurtosis = 1.7089
Variance = .2123637
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
=========================

<= 0	= 0%
<= 0	= 5%
<= 0	= 10%
<= 0	= 15%
<= 0	= 20%
<= 0	= 25%
<= 0	= 30%
<= 0	= 35%
<= 0	= 40%
<= 0	= 45%
<= 0	= 50%
<= 0	= 55%
<= 0	= 60%
<= 0	= 65%
<= 1	= 70%
<= 1	= 75%
<= 1	= 80%
<= 1	= 85%
<= 1	= 90%
<= 1	= 95%
<= 1	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=.15	= 30.6%
>=.3	= 30.6%
>=.45	= 30.6%
>=.6	= 30.6%
>=.75	= 30.6%
>=.9	= 30.6%
>=1.05	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(0,1,.695,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,.305,20)

MFG RQN (Sim #2 in Cell F41)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = .85
Maximum Result = 3
Minimum Result = 0
Range of Possible Results = 3
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = .5792246
Skewness = .2076355
Kurtosis = 3.628344
Variance = .3355011
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 0	= 0%
<= 0	= 5%
<= 0	= 10%
<= 0	= 15%
<= 0	= 20%
<= 0	= 25%
<= 1	= 30%
<= 1	= 35%
<= 1	= 40%
<= 1	= 45%
<= 1	= 50%
<= 1	= 55%
<= 1	= 60%
<= 1	= 65%
<= 1	= 70%
<= 1	= 75%
<= 1	= 80%
<= 1	= 85%
<= 1	= 90%
<= 2	= 95%
<= 3	= 100%

Probabilities for Selected Values:
===========================

Probability of Result

> 0	= 100%
>=.4	= 75.2%
>=.8	= 75.2%
>=1.2	= 9.2%
>=1.6	= 9.2%
>=2	= 9.2%
>=2.4	= .6%
>=2.8	= .6%
>=3.2	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
===========================

@HISTOGRM(0,3,.25,0,0,0,0,0,.66,0,0,0,0,0,0,.085,0,0,0,0,0,.005,20)

MFG RQN (Sim #3 in Cell F41)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 2.082
Maximum Result = 7
Minimum Result = 0
Range of Possible Results = 7
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 1.181216
Skewness = .9842826
Kurtosis = 3.882091
Variance = 1.39527
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 0	= 0%
<= 1	= 5%
<= 1	= 10%
<= 1	= 15%
<= 1	= 20%
<= 1	= 25%
<= 1	= 30%
<= 1	= 35%
<= 2	= 40%
<= 2	= 45%
<= 2	= 50%
<= 2	= 55%
<= 2	= 60%
<= 2	= 65%
<= 2	= 70%
<= 3	= 75%
<= 3	= 80%
<= 3	= 85%
<= 4	= 90%
<= 4	= 95%
<= 7	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=.8	= 97.8%
>=1.6	= 63.6%
>=2.4	= 28.4%
>=3.2	= 13%
>=4	= 13%
>=4.8	= 4.2%
>=5.6	= 1%
>=6.4	= .2%
>=7.2	= 0%

Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(0,7,.02,0,.345,0,0,.35,0,0,.155,0,0,.09,0,0,.03,0,0,.005,0,.005,20)

MFG RQN (Sim #4 in Cell F41)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 4.232
Maximum Result = 14
Minimum Result = 1
Range of Possible Results = 13
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 2.36351
Skewness = 1.305425
Kurtosis = 5.060112
Variance = 5.586179
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 1	= 0%
<= 1	= 5%
<= 2	= 10%
<= 2	= 15%
<= 2	= 20%
<= 3	= 25%
<= 3	= 30%
<= 3	= 35%
<= 3	= 40%
<= 3	= 45%
<= 4	= 50%
<= 4	= 55%
<= 4	= 60%
<= 4	= 65%
<= 5	= 70%
<= 5	= 75%
<= 6	= 80%
<= 7	= 85%
<= 7	= 90%
<= 9	= 95%
<= 14	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=1.5	= 94.2%
>=3	= 77.6%
>=4.5	= 34.4%
>=6	= 23.8%
>=7.5	= 9.4%
>=9	= 5.8%
>=10.5	= 2.4%
>=12	= 1.6%
>=13.5	= .4%
>=15	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(1,14,.06,.165,0,.24,.19,0,.105,.085,0,.06,.035,0,.025,9.99999E-03,0,9.99999E-03,.005,0,.005,.005,20)

RETAIL DELY (Sim #1 in Cell F47)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 13.17369
Maximum Result = 29.30402
Minimum Result = 2.144222
Range of Possible Results = 27.15979
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.281947
Skewness = .3502166
Kurtosis = 2.319484
Variance = 39.46285
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 2.1442 = 0%
<= 3.702 = 5%
<= 5.2942 = 10%
<= 6.3754 = 15%
<= 7.2376 = 20%
<= 8.2633 = 25%
<= 9.0223 = 30%
<= 9.7804 = 35%
<= 10.7916= 40%
<= 11.5425= 45%
<= 12.4838= 50%
<= 13.673 = 55%
<= 14.5241= 60%
<= 15.3284= 65%
<= 16.1756= 70%
<= 17.5737= 75%
<= 19.0458= 80%
<= 20.8037= 85%
<= 22.0889= 90%
<= 24.4492= 95%
<= 29.304 = 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=3 = 97.6%
>=6 = 87.2%
>=9 = 70.2%
>=12 = 53.6%
>=15 = 38%
>=18 = 23.6%
>=21 = 13.6%
>=24 = 6%
>=27 = 1.4%
>=30 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(2.144222,29.30402,.043583,.041417,.054593,.073132,.080838,.088867,.07257,.07,.063389,.090454,.058529,.040018,.047611,.044282,.040718,.02925,.02075,.019149,.015852,.005,20)

RETAIL DELY (Sim #2 in Cell F47)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 13.07514
Maximum Result = 28.63587
Minimum Result = 1.301463
Range of Possible Results = 27.33441
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.205434
Skewness = .4685118
Kurtosis = 2.413298
Variance = 38.50742
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 1.3015 = 0%
<= 4.3389 = 5%
<= 5.7058 = 10%
<= 6.6958 = 15%
<= 7.4145 = 20%
<= 8.0861 = 25%
<= 8.7278 = 30%
<= 9.6123 = 35%
<= 10.291 = 40%
<= 11.0647= 45%
<= 11.991 = 50%
<= 13.0934= 55%
<= 13.9899= 60%
<= 15.0502= 65%
<= 16.2746= 70%
<= 17.5622= 75%
<= 18.9995= 80%
<= 20.2414= 85%
<= 22.0093= 90%
<= 24.2611= 95%
<= 28.6359= 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=3 = 98.2%
>=6 = 88.8%
>=9 = 69.4%
>=12 = 50%
>=15 = 36.2%
>=18 = 23%
>=21 = 11.8%
>=24 = 5.4%
>=27 = 2%
>=30 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(1.301463,28.63587,.01,.03,.038811,.079715,.098822,.077652,.095,.08,.065,.064534,.065466,.054107,.044207,.050796,.040889,.032348,.027298,.014147,.016207,.015,20)

RETAIL DELY (Sim #3 in Cell F47)
@RISK Risk Analysis
22-Oct-1991
=========================

Expected/Mean Result = 13.51152
Maximum Result = 29.49358
Minimum Result = 1.954981
Range of Possible Results = 27.5386
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.238772
Skewness = .3462724
Kurtosis = 2.254783
Variance = 38.92228
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
=========================

<= 1.955 = 0%
<= 4.5252 = 5%
<= 5.7269 = 10%
<= 6.6921 = 15%
<= 7.396 = 20%
<= 8.3196 = 25%
<= 9.2032 = 30%
<= 10.1783= 35%
<= 10.8932= 40%
<= 12.0008= 45%
<= 13.0695= 50%
<= 13.9628= 55%
<= 14.7509= 60%
<= 15.7955= 65%
<= 16.8332= 70%
<= 18.1846= 75%
<= 19.5675= 80%
<= 20.6166= 85%
<= 22.2549= 90%
<= 24.7123= 95%
<= 29.4936= 100%

Probabilities for Selected Values:
=========================

Probability of Result
> 0 = 100%
>=3 = 99.4%
>=6 = 89%
>=9 = 71%
>=12 = 55.2%
>=15 = 39.4%
>=18 = 25.8%
>=21 = 13.6%
>=24 = 6.6%
>=27 = 1.4%
>=30 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
=========================

@HISTOGRM(1.954981,29.49358,.015,.043166,.059921,.086913,.075,.072151,.087849,.055,.079905,.067641,.070828,.05024,.05055,.053583,.045087,.022165,.029172,.015827,.013626,.006374,20)

RETAIL DELY (Sim #4 in Cell F47)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = 13.26032
Maximum Result = 29.9276
Minimum Result = 2.783331
Range of Possible Results = 27.14426
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.073074
Skewness = .4891376
Kurtosis = 2.492248
Variance = 36.88223
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<=	2.7833	= 0%
<=	4.5383	= 5%
<=	5.7444	= 10%
<=	6.907	= 15%
<=	7.5906	= 20%
<=	8.2684	= 25%
<=	9.3978	= 30%
<=	10.0722	= 35%
<=	10.8315	= 40%
<=	11.5806	= 45%
<=	12.4957	= 50%
<=	13.3603	= 55%
<=	14.1381	= 60%
<=	15.0479	= 65%
<=	15.9162	= 70%
<=	17.2073	= 75%
<=	18.4926	= 80%
<=	20.5969	= 85%
<=	22.02	= 90%
<=	24.6081	= 95%
<=	29.9276	= 100%

Probabilities for Selected Values:
===========================

Probability of Result

> 0	= 100%
>=3	= 99.4%
>=6	= 88.8%
>=9	= 71%
>=12	= 53.4%
>=15	= 35.4%
>=18	= 22%
>=21	= 13.8%
>=24	= 6.6%
>=27	= 1.6%
>=30	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
===========================

@HISTOGRM(2.783331,29.9276,.029155,.057997,.060736,.097111,.06466,.097781,.077395,.084591,.078389,.072185,.055,.033259,.035899,.045841,.037826,.020158,.02402,.016617,.005881,.005499,20)

RETAIL RQN (Sim #1 in Cell F35)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 126.388
Maximum Result = 142
Minimum Result = 113
Range of Possible Results = 29
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.404177
Skewness = .1806537
Kurtosis = 2.23704
Variance = 41.01348
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 113	= 0%
<= 116	= 5%
<= 118	= 10%
<= 119	= 15%
<= 120	= 20%
<= 121	= 25%
<= 123	= 30%
<= 123	= 35%
<= 124	= 40%
<= 125	= 45%
<= 126	= 50%
<= 127	= 55%
<= 128	= 60%
<= 129	= 65%
<= 130	= 70%
<= 131	= 75%
<= 132	= 80%
<= 134	= 85%
<= 135	= 90%
<= 138	= 95%
<= 142	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=105	= 100%
>=110	= 100%
>=115	= 99%
>=120	= 83.6%
>=125	= 58.4%
>=130	= 32%
>=135	= 11.2%
>=140	= 1.4%
>=145	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(113,142,.01,.02,.05,.03,.1,.05,.095,.06,.115,.03,.075,.08,.055,.07,.05,.04,9.99999E-03,.045,.01,.005,20)

RETAIL RQN (Sim #2 in Cell F35)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 252.58
Maximum Result = 284
Minimum Result = 225
Range of Possible Results = 59
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 12.69928
Skewness = .2663135
Kurtosis = 2.388762
Variance = 161.2717
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 225	= 0%
<= 234	= 5%
<= 237	= 10%
<= 239	= 15%
<= 241	= 20%
<= 243	= 25%
<= 245	= 30%
<= 246	= 35%
<= 248	= 40%
<= 250	= 45%
<= 251	= 50%
<= 253	= 55%
<= 256	= 60%
<= 257	= 65%
<= 259	= 70%
<= 261	= 75%
<= 264	= 80%
<= 267	= 85%
<= 270	= 90%
<= 275	= 95%
<= 284	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=232.5	= 96%
>=240	= 83.6%
>=247.5	= 60.6%
>=255	= 42.8%
>=262.5	= 23%
>=270	= 11.4%
>=277.5	= 3%
>=285	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(225,284,.01,.02,.015,.04,.08,.07,.095,.085,.09,.065,.095,.07,.055,.04,.055,.035,.035,.02,.015,.01,20)

RETAIL RQN (Sim #3 in Cell F35)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 631.474
Maximum Result = 710
Minimum Result = 565
Range of Possible Results = 145
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 32.30966
Skewness = .2573369
Kurtosis = 2.365767
Variance = 1043.914
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 565	= 0%
<= 582	= 5%
<= 590	= 10%
<= 596	= 15%
<= 604	= 20%
<= 608	= 25%
<= 612	= 30%
<= 616	= 35%
<= 618	= 40%
<= 622	= 45%
<= 627	= 50%
<= 634	= 55%
<= 639	= 60%
<= 644	= 65%
<= 648	= 70%
<= 655	= 75%
<= 660	= 80%
<= 668	= 85%
<= 677	= 90%
<= 688	= 95%
<= 710	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=440	= 100%
>=480	= 100%
>=520	= 100%
>=560	= 100%
>=600	= 83%
>=640	= 40%
>=680	= 9%
>=720	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(565,710,.018125,.024375,.03125,.05625,.045,.0825,.09125,.11125,.06,.0675,.06625,.07375,.0675,.0425,.042083,.035417,.035,.0225,.016875,.010625,20)

RETAIL RQN (Sim #4 in Cell F35)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 1259.136
Maximum Result = 1408
Minimum Result = 1137
Range of Possible Results = 271
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 58.14951
Skewness = .3246908
Kurtosis = 2.493458
Variance = 3381.366
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 1137	= 0%
<= 1171	= 5%
<= 1187	= 10%
<= 1200	= 15%
<= 1207	= 20%
<= 1217	= 25%
<= 1224	= 30%
<= 1230	= 35%
<= 1237	= 40%
<= 1245	= 45%
<= 1252	= 50%
<= 1261	= 55%
<= 1269	= 60%
<= 1278	= 65%
<= 1289	= 70%
<= 1300	= 75%
<= 1311	= 80%
<= 1327	= 85%
<= 1341	= 90%
<= 1363	= 95%
<= 1408	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=1050	= 100%
>=1100	= 100%
>=1150	= 98.4%
>=1200	= 85.2%
>=1250	= 51.6%
>=1300	= 25.2%
>=1350	= 8.2%
>=1400	= .4%
>=1450	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(1137,1408,.017125,.020458,.030667,.0495,.061,.08125,.094625,.097375,.090375,.080125,.0625,.063,.060584,.040666,.049813,.025688,.032344,.017906,.018625,.006375,20)

TOTAL CUM DAYS (Sim #1 in Cell H53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 56.9178
Maximum Result = 107.0924
Minimum Result = 21.71073
Range of Possible Results = 85.38168
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 16.50245
Skewness = .6638557
Kurtosis = 3.034617
Variance = 272.3308
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 21.7107= 0%
<= 34.6733= 5%
<= 38.1967= 10%
<= 40.579 = 15%
<= 42.7538= 20%
<= 44.3362= 25%
<= 46.787 = 30%
<= 48.6391= 35%
<= 50.6653= 40%
<= 51.8606= 45%
<= 53.4398= 50%
<= 55.5488= 55%
<= 58.1149= 60%
<= 61.4285= 65%
<= 64.0841= 70%
<= 66.2157= 75%
<= 70.5002= 80%
<= 74.9053= 85%
<= 81.3867= 90%
<= 86.6633= 95%
<= 107.0924= 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=15 = 100%
>=30 = 98%
>=45 = 73.6%
>=60 = 37.2%
>=75 = 15%
>=90 = 3.6%
>=105 = .4%
>=120 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(21.71073,107.0924,.007155,.016149,.025875,.060018,.100802,.11,.12,.117702,.072298,.08,.065,.052506,.031558,.040936,.039194,.025806,.008641,.011359,.004709,.010291,20)

TOTAL CUM DAYS (Sim #2 in Cell H53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 69.32502
Maximum Result = 117.4624
Minimum Result = 18.53136
Range of Possible Results = 98.93104
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 17.6418
Skewness = -.1290325
Kurtosis = 2.753456
Variance = 311.2332
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 18.5314= 0%
<= 38.6222= 5%
<= 43.5541= 10%
<= 49.9779= 15%
<= 54.0764= 20%
<= 57.2608= 25%
<= 61.1778= 30%
<= 63.2249= 35%
<= 65.8007= 40%
<= 68.0627= 45%
<= 70.9496= 50%
<= 73.1044= 55%
<= 74.4338= 60%
<= 76.0611= 65%
<= 79.0438= 70%
<= 80.7301= 75%
<= 83.7637= 80%
<= 86.7373= 85%
<= 90.8032= 90%
<= 98.2879= 95%
<= 117.4624= 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>= 5 = 100%
>=30 = 99%
>=45 = 89.8%
>=60 = 71.8%
>=75 = 38.4%
>=90 = 10.6%
>=105 = 1.4%
>=120 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(18.53136,117.4624,.003197,.006667,.015136,.023151,.048868,.037488,.055031,.065105,.090358,.104305,.090648,.145047,.098966,.076034,.049622,.035378,.03,.013322,.006678,.005,20)

TOTAL CUM DAYS (Sim #3 in Cell H53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 75.88338
Maximum Result = 118.3359
Minimum Result = 21.41432
Range of Possible Results = 96.92158
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 14.01106
Skewness = 2.314885E-02
Kurtosis = 3.403512
Variance = 196.3099
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 21.4143= 0%
<= 54.5878= 5%
<= 58.0077= 10%
<= 61.507 = 15%
<= 64.575 = 20%
<= 66.7952= 25%
<= 68.3273= 30%
<= 69.9926= 35%
<= 72.1334= 40%
<= 73.8573= 45%
<= 75.711 = 50%
<= 77.428 = 55%
<= 79.0568= 60%
<= 81.0908= 65%
<= 83.2573= 70%
<= 85.2189= 75%
<= 87.3276= 80%
<= 90.1233= 85%
<= 92.7087= 90%
<= 98.0293= 95%
<= 118.3359=100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=15 = 100%
>=30 = 99.8%
>=45 = 99%
>=60 = 87.6%
>=75 = 51.8%
>=90 = 15.2%
>=105 = 2.8%
>=120 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(21.41432,118.3359,0,.00385,0,.003311,.006689,.014715,.035078,.065051,.08269,.135297,.12717,.139589,.102812,.111278,.086322,.04,.015,.017059,.007941,.005,20)

TOTAL CUM DAYS (Sim #4 in Cell H53)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 76.36497
Maximum Result = 118.7925
Minimum Result = 42.49953
Range of Possible Results = 76.29297
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 13.31862
Skewness = .2097851
Kurtosis = 2.798884
Variance = 177.3856
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 42.4995	= 0%
<= 55.5978	= 5%
<= 60.2671	= 10%
<= 62.8551	= 15%
<= 64.7694	= 20%
<= 66.1702	= 25%
<= 68.5376	= 30%
<= 70.7014	= 35%
<= 72.2786	= 40%
<= 74.1326	= 45%
<= 75.4519	= 50%
<= 77.3137	= 55%
<= 79.6464	= 60%
<= 80.959	= 65%
<= 82.8834	= 70%
<= 85.1689	= 75%
<= 87.7536	= 80%
<= 90.7776	= 85%
<= 94.1205	= 90%
<= 99.3409	= 95%
<= 118.7925	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=15	= 100%
>=30	= 100%
>=45	= 99.8%
>=60	= 90.2%
>=75	= 52.6%
>=90	= 16%
>=105	= 2%
>=120	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(42.49953,118.7925,.01,.009596,.019442,.034191,.048808,.095405,.101708,.103669,.11469,.097491,.102505,.067495,.07,.043354,.036532,.022996,.01179,.005328,.002925,2.07454E-03,20)

WHOLESALE DELY (Sim #1 in Cell F51)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 20.33442
Maximum Result = 39.35078
Minimum Result = 5.858191
Range of Possible Results = 33.49259
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.209728
Skewness = .308111
Kurtosis = 2.71006
Variance = 38.56072
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 5.8582	= 0%
<= 10.7518	= 5%
<= 12.6249	= 10%
<= 13.79	= 15%
<= 14.4908	= 20%
<= 15.7665	= 25%
<= 16.653	= 30%
<= 17.6133	= 35%
<= 18.3493	= 40%
<= 19.119	= 45%
<= 19.8982	= 50%
<= 20.6433	= 55%
<= 21.5011	= 60%
<= 22.5171	= 65%
<= 23.5749	= 70%
<= 24.4179	= 75%
<= 25.7692	= 80%
<= 27.0679	= 85%
<= 28.6699	= 90%
<= 31.1405	= 95%
<= 39.3508	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=4	= 100%
>=8	= 98.8%
>=12	= 92%
>=16	= 73.4%
>=20	= 49.8%
>=24	= 26.8%
>=28	= 12.2%
>=32	= 3.8%
>=36	= 1%
>=40	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(5.858191,39.35078,.01,.005,.037941,.042059,.08735,.07765,.087409,.117591,.1,.097198,.082461,.070341,.055,.047026,.031432,.021242,.014996,.005305,.005,.005,20)

WHOLESALE DELY (Sim #2 in Cell F51)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = 20.38225
Maximum Result = 39.73785
Minimum Result = 5.408826
Range of Possible Results = 34.32902
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.526924
Skewness = .2462716
Kurtosis = 2.491487
Variance = 42.60074
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 5.4088	= 0%
<= 10.523	= 5%
<= 12.3168	= 10%
<= 13.3385	= 15%
<= 14.4136	= 20%
<= 15.204	= 25%
<= 16.2039	= 30%
<= 17.1706	= 35%
<= 18.1697	= 40%
<= 19.018	= 45%
<= 20.1369	= 50%
<= 21.2217	= 55%
<= 22.0299	= 60%
<= 22.9257	= 65%
<= 23.6502	= 70%
<= 24.6466	= 75%
<= 26.1155	= 80%
<= 27.8175	= 85%
<= 29.6724	= 90%
<= 31.4859	= 95%
<= 39.7379	= 100%

Probabilities for Selected Values:
===========================

Probability of Result	
> 0	= 100%
>=4	= 100%
>=8	= 99%
>=12	= 91%
>=16	= 71%
>=20	= 50.4%
>=24	= 28.2%
>=28	= 14.4%
>=32	= 3.8%
>=36	= 1%
>=40	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
===========================

@HISTOGRM(5.408826,39.73785,.007215,.021414,.021371,.049254,.078709,.104149,.082888,.09,.077355,.090497,.112149,.062464,.049696,.047348,.047751,.032741,9.99999E-03,.008107,.003965,.002927,20)

WHOLESALE DELY (Sim #3 in Cell F51)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 20.52019
Maximum Result = 37.64407
Minimum Result = 4.729002
Range of Possible Results = 32.91507
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.248168
Skewness = .2872512
Kurtosis = 2.630462
Variance = 39.0396
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 4.729 = 0%
<= 11.0646= 5%
<= 12.9025= 10%
<= 14.0375= 15%
<= 14.9679= 20%
<= 15.9272= 25%
<= 16.9455= 30%
<= 17.6366= 35%
<= 18.3034= 40%
<= 19.108 = 45%
<= 19.8035= 50%
<= 20.57 = 55%
<= 21.6536= 60%
<= 22.4439= 65%
<= 23.8094= 70%
<= 24.8205= 75%
<= 26.0467= 80%
<= 27.4312= 85%
<= 29.1877= 90%
<= 31.7878= 95%
<= 37.6441= 100%

Probabilities for Selected Values:
==========================

Probability of Result
> 0 = 100%
>=4 = 100%
>=8 = 98.6%
>=12 = 92.8%
>=16 = 74.6%
>=20 = 48.6%
>=24 = 29%
>=28 = 12.6%
>=32 = 4.6%
>=36 = .4%
>=40 = 0%
Probability of Result
<= 0 = 0%
@Function For This Output Distribution:
==========================

@HISTOGRM(4.729002,37.64407,.005,.01,.009199,.030801,.05,.07,.09,.103216,.120763,.090335,.080687,.068841,.076159,.059654,.040346,.028674,.036326,9.99999E-03,.015,.005,20)

WHOLESALE DELY (Sim #4 in Cell F51)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 20.24231
Maximum Result = 37.81224
Minimum Result = 6.264636
Range of Possible Results = 31.54761
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 6.185397
Skewness = .193821
Kurtosis = 2.448405
Variance = 38.25913
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 6.2646	= 0%
<= 10.6953	= 5%
<= 12.6554	= 10%
<= 13.5074	= 15%
<= 14.6146	= 20%
<= 15.3135	= 25%
<= 16.3732	= 30%
<= 17.1841	= 35%
<= 17.8986	= 40%
<= 18.8902	= 45%
<= 19.711	= 50%
<= 20.7677	= 55%
<= 21.8389	= 60%
<= 22.782	= 65%
<= 23.6311	= 70%
<= 25.191	= 75%
<= 26.0931	= 80%
<= 27.0499	= 85%
<= 28.3916	= 90%
<= 30.2219	= 95%
<= 37.8122	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=4	= 100%
>=8	= 99%
>=12	= 92.8%
>=16	= 71.4%
>=20	= 49%
>=24	= 29.2%
>=28	= 12.2%
>=32	= 3%
>=36	= .6%
>=40	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(6.264636,37.81224,.01,.02,.03,.03,.088057,.09567,.086273,.089166,.080834,.079876,.088882,.051242,.085,.06,.047759,.026222,.009568,.013577,.005087,.002787,20)

WHOLESALE RQN (Sim #1 in Cell F39)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 3.116
Maximum Result = 8
Minimum Result = 1
Range of Possible Results = 7
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 1.197724
Skewness = .5862097
Kurtosis = 3.289086
Variance = 1.434543
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 1	= 0%
<= 1	= 5%
<= 2	= 10%
<= 2	= 15%
<= 2	= 20%
<= 2	= 25%
<= 2	= 30%
<= 3	= 35%
<= 3	= 40%
<= 3	= 45%
<= 3	= 50%
<= 3	= 55%
<= 3	= 60%
<= 3	= 65%
<= 4	= 70%
<= 4	= 75%
<= 4	= 80%
<= 4	= 85%
<= 5	= 90%
<= 5	= 95%
<= 8	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=.9	= 100%
>=1.8	= 94.6%
>=2.7	= 66.6%
>=3.6	= 33%
>=4.5	= 13.4%
>=5.4	= 3.2%
>=6.3	= .6%
>=7.2	= .2%
>=9	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(1,8,.055,0,.28,0,0,.335,0,0,.195,0,0,.105,0,0,.025,0,0,0,0,.005,20)

WHOLESALE RQN (Sim #2 in Cell F39)
@RISK Risk Analysis
22-Oct-1991
===========================

Expected/Mean Result = 5.856
Maximum Result = 14
Minimum Result = 1
Range of Possible Results = 13
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 2.470479
Skewness = .7441041
Kurtosis = 3.417202
Variance = 6.103268
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
===========================

<= 1	= 0%
<= 2	= 5%
<= 3	= 10%
<= 3	= 15%
<= 4	= 20%
<= 4	= 25%
<= 4	= 30%
<= 5	= 35%
<= 5	= 40%
<= 5	= 45%
<= 5	= 50%
<= 6	= 55%
<= 6	= 60%
<= 6	= 65%
<= 7	= 70%
<= 7	= 75%
<= 8	= 80%
<= 8	= 85%
<= 9	= 90%
<= 11	= 95%
<= 14	= 100%

Probabilities for Selected Values:
===========================

Probability of Result

> 0	= 100%
>=1.5	= 99.6%
>=3	= 95%
>=4.5	= 67.6%
>=6	= 49.8%
>=7.5	= 23.4%
>=9	= 13.4%
>=10.5	= 5.4%
>=12	= 3.4%
>=13.5	= .6%
>=15	= 0%

Probability of Result

<= 0	= 0%

@Function For This Output Distribution:
===========================

@HISTOGRM(1,14,.005,.045,0,.12,.155,0,.175,.15,0,.115,.1,0,.055,.025,0,.02,.02,0,.01,.005,20)

WHOLESALE RQN (Sim #3 in Cell F39)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 14.528
Maximum Result = 30
Minimum Result = 3
Range of Possible Results = 27
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 5.819039
Skewness = .4241818
Kurtosis = 2.633412
Variance = 33.86122
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 3	= 0%
<= 6	= 5%
<= 7	= 10%
<= 8	= 15%
<= 9	= 20%
<= 10	= 25%
<= 11	= 30%
<= 12	= 35%
<= 13	= 40%
<= 13	= 45%
<= 14	= 50%
<= 15	= 55%
<= 16	= 60%
<= 16	= 65%
<= 17	= 70%
<= 18	= 75%
<= 19	= 80%
<= 21	= 85%
<= 23	= 90%
<= 25	= 95%
<= 30	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=4	= 99.6%
>=8	= 89%
>=12	= 66.8%
>=16	= 40.4%
>=20	= 19.8%
>=24	= 9.2%
>=28	= 2%
>=32	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(3,30,.02,.02,.07,.06,.05,.11,.065,.075,.125,.075,.04,.09,.045,.025,.04,.02,.02,.03,9.99999E-03,.01,20)

WHOLESALE RQN (Sim #4 in Cell F39)
@RISK Risk Analysis
22-Oct-1991
==========================

Expected/Mean Result = 30.212
Maximum Result = 72
Minimum Result = 8
Range of Possible Results = 64
Probability of Positive Result = 100%
Probability of Negative Result = 0%
Standard Deviation = 12.13091
Skewness = .7773132
Kurtosis = 3.411167
Variance = 147.1589
ERRs Calculated = 0
Values Filtered = 0
Simulations Executed = 4
Iterations = 500

Percentile Probabilities:
(Chance of Result <= Shown Value)
(Actual Values)
==========================

<= 8	= 0%
<= 13	= 5%
<= 16	= 10%
<= 18	= 15%
<= 20	= 20%
<= 21	= 25%
<= 23	= 30%
<= 24	= 35%
<= 26	= 40%
<= 27	= 45%
<= 28	= 50%
<= 30	= 55%
<= 31	= 60%
<= 32	= 65%
<= 34	= 70%
<= 37	= 75%
<= 40	= 80%
<= 44	= 85%
<= 46	= 90%
<= 53	= 95%
<= 72	= 100%

Probabilities for Selected Values:
==========================

Probability of Result

> 0	= 100%
>=8	= 100%
>=16	= 91.4%
>=24	= 67.4%
>=32	= 37.8%
>=40	= 20.4%
>=48	= 9.6%
>=56	= 3.6%
>=64	= 1.4%
>=72	= .2%
>=80	= 0%

Probability of Result
<= 0 = 0%

@Function For This Output Distribution:
==========================

@HISTOGRM(8,72,.025,.045,.06,.085,.11,.145,.12,.09,.05,.065,.045,.06,.015,.03,.02,9.99999E-03,9.99999E-03,.005,.005,.005,20)

APPENDIX C

SIMFACTORY II.5 SELECTED SIMULATION REPORTS

SFII.5 (v3.02) TESTG HISTOGRAM SUMMARY STATISTICS 10/22/1991
19:02

(Data collected for 2000.0 DAYS in 20 replications)

COMP REQN MAKESPAN HISTOGRAM

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	8	.27	.27
5.01 to 10.00	311	10.37	10.63
10.01 to 15.00	774	25.80	36.43
15.01 to 20.00	842	28.07	64.50
20.01 to 25.00	622	20.73	85.23
25.01 to 30.00	351	11.70	96.93
30.01 to 35.00	84	2.80	99.73
35.01 to 40.00	6	.20	99.93
40.01 to 45.00	0	0.	99.93
45.01 to 50.00	0	0.	99.93
50.01 to 55.00	1	.03	99.97
55.01 to 60.00	1	.03	100.00
60.01 to 65.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	3000	100.00	

CVN BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

CVN DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	3000	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	3000	100.00	

FACTORYQ BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

FACTORYQ DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	5	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	5	100.00	

ICPQ BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

ICPQ DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	73	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	73	100.00	

INVQ BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

INVQ DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	3000	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	3000	100.00	

NSCQ BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

NSCQ DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	3000	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	3000	100.00	

SPQ BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

SPQ DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	551	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	551	100.00	

SUPSHIPNN BUFFER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

SUPSHIPNN DELAY IN BUFFER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	3000	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	3000	100.00	

FAC-INVC CHAMBER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

FAC-INVC DELAY IN CHAMBER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	1	20.00	20.00
5.01 to 10.00	0	0.	20.00
10.01 to 15.00	1	20.00	40.00
15.01 to 20.00	0	0.	40.00
20.01 to 25.00	3	60.00	100.00
25.01 to 30.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	5	100.00	

FACC CHAMBER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

FACC DELAY IN CHAMBER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	0	0.	0.
5.01 to 10.00	1	20.00	20.00
10.01 to 15.00	2	40.00	60.00
15.01 to 20.00	1	20.00	80.00
20.01 to 25.00	0	0.	80.00
25.01 to 30.00	1	20.00	100.00
30.01 to 35.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	5	100.00	

ICP-FACC CHAMBER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	2000.00	100.00	100.00
6 to 10	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

ICP-FACC DELAY IN CHAMBER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	4	80.00	80.00
5.01 to 10.00	1	20.00	100.00
10.01 to 15.00	0	0.	100.00
15.01 to 20.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	5	100.00	

ICP-INVC CHAMBER LEVEL HISTOGRAM

Range			Time	Percent	Cumulative %
0	to	5	1970.26	98.51	98.51
6	to	10	29.74	1.49	100.00
11	to	15	0.00	0.	100.00
101	to	∞	0.00	0.	100.00
			2000	100.00	

ICP-INVC DELAY IN CHAMBER

Range			Frequency	Percent	Cumulative %
0.00	to	5.00	3	4.41	4.41
5.01	to	10.00	11	16.18	20.59
10.01	to	15.00	26	38.24	58.82
15.01	to	20.00	19	27.94	86.76
20.01	to	25.00	5	7.35	94.12
25.01	to	30.00	4	5.88	100.00
30.01	to	35.00	0	0.	100.00
100.01	to	∞	0	0.	100.00
			68	100.00	

INVC-CVN CHAMBER LEVEL HISTOGRAM

Range			Time	Percent	Cumulative %
0	to	5	1506.72	75.34	75.34
6	to	10	80.65	4.03	79.37
11	to	15	79.00	3.95	83.32
16	to	20	96.67	4.83	88.15
21	to	25	71.02	3.55	91.70
26	to	30	86.94	4.35	96.05
31	to	35	52.91	2.65	98.70
36	to	40	21.27	1.06	99.76
41	to	45	3.03	.15	99.91
46	to	50	1.54	.08	99.99
51	to	55	0.25	.01	100.00
56	to	60	0.00	0.	100.00
101	to	∞	0.00	0.	100.00
			2000	100.00	

INVC-CVN DELAY IN CHAMBER

Range			Frequency	Percent	Cumulative %
0.00	to	5.00	2535	84.50	84.50
5.01	to	10.00	465	15.50	100.00
10.01	to	15.00	0	0.	100.00
100.01	to	∞	0	0.	100.00
			3000	100.00	

NSC-INV CHAMBER LEVEL HISTOGRAM

Range			Time	Percent	Cumulative %
0	to	5	1504.40	75.22	75.22
6	to	10	34.55	1.73	76.95
11	to	15	24.71	1.24	78.18
16	to	20	27.47	1.37	79.56
21	to	25	23.99	1.20	80.76
26	to	30	18.78	.94	81.70
31	to	35	15.58	.78	82.47
36	to	40	20.80	1.04	83.51
41	to	45	19.67	.98	84.50
46	to	50	15.63	.78	85.28
51	to	55	13.02	.65	85.93
56	to	60	14.94	.75	86.68
61	to	65	12.79	.64	87.32
66	to	70	15.48	.77	88.09
71	to	75	11.31	.57	88.66
76	to	80	15.31	.77	89.42
81	to	85	12.04	.60	90.02
86	to	90	12.52	.63	90.65
91	to	95	12.68	.63	91.28
96	to	100	15.95	.80	92.08
101	to	∞	158.37	7.92	100.00
			2000	100.00	

NSC-INV DELAY IN CHAMBER

Range			Frequency	Percent	Cumulative %
0.00	to	5.00	143	5.84	5.84
5.01	to	10.00	605	24.70	30.54
10.01	to	15.00	727	29.69	60.23
15.01	to	20.00	521	21.27	81.50
20.01	to	25.00	338	13.80	95.30
25.01	to	30.00	115	4.70	100.00
30.01	to	35.00	0	0.	100.00
100.01	to	∞	0	0.	100.00
			2449	100.00	

NSC-SP CHAMBER LEVEL HISTOGRAM

Range			Time	Percent	Cumulative %
0	to	5	1986.98	99.35	99.35
6	to	10	2.05	.10	99.45
11	to	15	1.61	.08	99.53
16	to	20	2.20	.11	99.64
21	to	25	3.07	.15	99.80
26	to	30	2.50	.12	99.92
31	to	35	1.60	.08	100.00
36	to	40	0.00	0.	100.00
101	to	∞	0.00	0.	100.00
			2000	100.00	

NSC-SP DELAY IN CHAMBER

Range			Frequency	Percent	Cumulative %
0.00	to	5.00	551	100.00	100.00
5.01	to	10.00	0	0.	100.00
100.01	to	∞	0	0.	100.00
			551	100.00	

SP-ICP CHAMBER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	1998.96	99.95	99.95
6 to 10	1.04	.05	100.00
11 to 15	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

SP-ICP DELAY IN CHAMBER

Range	Frequency	Percent	Cumulative %
0.00 to 5.00	73	100.00	100.00
5.01 to 10.00	0	0.	100.00
100.01 to ∞	0	0.	100.00
	73	100.00	

SP-INV CHAMBER LEVEL HISTOGRAM

Range	Time	Percent	Cumulative %
0 to 5	1587.40	79.37	79.37
6 to 10	91.71	4.59	83.96
11 to 15	68.57	3.43	87.38
16 to 20	112.48	5.62	93.01
21 to 25	82.00	4.10	97.11
26 to 30	51.18	2.56	99.67
31 to 35	6.66	.33	100.00
36 to 40	0.00	0.	100.00
101 to ∞	0.00	0.	100.00
	2000	100.00	

SP-INV DELAY IN CHAMBER

Range			Frequency	Percent	Cumulative %
0.00	to	5.00	8	1.67	1.67
5.01	to	10.00	76	15.90	17.57
10.01	to	15.00	147	30.75	48.33
15.01	to	20.00	122	25.52	73.85
20.01	to	25.00	102	21.34	95.19
25.01	to	30.00	23	4.81	100.00
30.01	to	35.00	0	0.	100.00
100.01	to	∞	0	0.	100.00
			478	100.00	

SFII.5 (v3.02) TESTG BUFFER SUMMARY STATISTICS 10/22/1991 19:02
(Data collected for 2000.0 DAYS in 20 replications)

Statistic	Level Minimum	Level Average	Level Maximum	Delay Minimum	Delay Average	Delay Maximum	Parts
			--- CVN ---				
Mean	0	0.00	1	0.00	0.00	0.00	150.00
Std. Dev.		0.00			0.00		0.00
Lower C.I.		0.00			0.00		150.00
Upper C.I.		0.00			0.00		150.00
			--- FACTORYQ ---				
Mean	0	0.00	1	0.00	0.00	0.00	0.25
Std. Dev.		0.00			0.00		0.44
Lower C.I.		0.00			0.00		0.08
Upper C.I.		0.00			0.00		0.42
			--- ICPQ ---				
Mean	0	0.00	1	0.00	0.00	0.00	3.65
Std. Dev.		0.00			0.00		2.32
Lower C.I.		0.00			0.00		2.75
Upper C.I.		0.00			0.00		4.55
			--- INVQ ---				
Mean	0	0.00	1	0.00	0.00	0.00	150.00
Std. Dev.		0.00			0.00		0.00
Lower C.I.		0.00			0.00		150.00
Upper C.I.		0.00			0.00		150.00
			--- NSCQ ---				
Mean	0	0.00	150	0.00	0.00	0.00	150.00
Std. Dev.		0.00			0.00		0.00
Lower C.I.		0.00			0.00		150.00
Upper C.I.		0.00			0.00		150.00
			--- SPQ ---				
Mean	0	0.00	1	0.00	0.00	0.00	27.55
Std. Dev.		0.00			0.00		4.63
Lower C.I.		0.00			0.00		25.76
Upper C.I.		0.00			0.00		29.34
			--- SUPSHIPNN ---				
Mean	0	0.00	150	0.00	0.00	0.00	150.00
Std. Dev.		0.00			0.00		0.00
Lower C.I.		0.00			0.00		150.00
Upper C.I.		0.00			0.00		150.00

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SFII.5 (v3.02) TESTG CHAMBER STATION SUMMARY STATISTICS 10/22/1991 19:02

(Data collected for 2000.0 DAYS in 20 replications)

Statistic	Level Minimum	Level Average	Level Maximum	Delay Minimum	Delay Average	Delay Maximum	Parts
--- FAC-INVC ---							
Mean	0	0.04	1	3.94	4.21	23.15	0.25
Std. Dev.		0.08			8.39		0.44
Lower C.I.		0.01			0.96		0.08
Upper C.I.		0.07			7.45		0.42
--- FACC ---							
Mean	0	0.04	1	5.02	3.78	26.00	0.25
Std. Dev.		0.08			7.56		0.44
Lower C.I.		0.01			0.85		0.08
Upper C.I.		0.07			6.70		0.42
--- ICP-FACC ---							
Mean	0	0.01	1	3.43	1.07	5.39	0.25
Std. Dev.		0.02			1.93		0.44
Lower C.I.		0.00			0.32		0.08
Upper C.I.		0.02			1.82		0.42
--- ICP-INVC ---							
Mean	0	0.48	8	2.47	14.57	28.95	3.40
Std. Dev.		0.29			3.90		2.01
Lower C.I.		0.37			13.06		2.62
Upper C.I.		0.60			16.08		4.18
--- INVC-CVN ---							
Mean	0	5.27	51	0.59	3.51	6.91	150.00
Std. Dev.		0.18			0.12		0.00
Lower C.I.		5.20			3.47		150.00
Upper C.I.		5.34			3.56		150.00
--- NSC-INV ---							
Mean	0	16.99	131	1.90	13.87	29.85	122.45
Std. Dev.		1.12			0.73		4.63
Lower C.I.		16.55			13.59		120.66
Upper C.I.		17.42			14.16		124.24
--- NSC-SP ---							
Mean	0	0.14	34	0.07	0.51	0.97	27.55
Std. Dev.		0.03			0.03		4.63
Lower C.I.		0.13			0.49		25.76
Upper C.I.		0.15			0.52		29.34
--- SP-ICP ---							
Mean	0	0.02	8	0.10	0.58	0.98	3.65
Std. Dev.		0.01			0.11		2.32
Lower C.I.		0.02			0.54		2.75
Upper C.I.		0.03			0.63		4.55
--- SP-INV ---							
Mean	0	3.74	31	2.79	15.73	29.10	23.90
Std. Dev.		0.57			0.93		4.22
Lower C.I.		3.52			15.37		22.27
Upper C.I.		3.96			16.09		25.53

SFII.5 (v3.02) TESTG PROCESSING STATION SUMMARY STATISTICS 10/22/1991 19:02

(Data collected for 2000.0 DAYS in 20 replications)

Statistic	Work	Setup	Trdwn	Prty	Pass	Idle	Blockd	Reqst	Parts
				Status (%)					
				--- CVN1 ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
				--- ICP ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	3.65
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32
Lower C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	2.75
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	4.55
				--- ICP-2 ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.25
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.44
Lower C.I.	0.00	0.00	0.00	0.00	0.00	99.99	0.00	0.00	0.08
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.42
				--- INVENTORY1 ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Lower C.I.	0.00	0.00	0.00	0.00	0.00	99.99	0.00	0.00	150.00
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
				--- NSC ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	150.00
				--- STOCK POINT ---					
Mean	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	27.55
Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
Lower C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	25.76
Upper C.I.	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	29.34

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SFII.5 (v3.02) TESTG PART STATUS SUMMARY STATISTICS 10/22/1991 19:02
(Data collected for 2000.0 DAYS in 20 replications)

Raw Material

Part Name	Buffer	Statistic	Number Consumed
NEW REQN	SUPSHIPNN	Mean	150.00
		Std. Dev.	0.00
		Lower C.I.	150.00
		Upper C.I.	150.00

Final Products

Part Name	Statistic	Number Made	--- Product Make Span ---- Minimum	Average	Maximum
COMP REQN	Mean	150.00	3.70	17.82	58.50
	Std. Dev.	0.00		0.60	
	Lower C.I.	150.00		17.59	
	Upper C.I.	150.00		18.05	

Work In Process

Part Name	Statistic	Number Completed	---- Status (%) ---- Busy	Idle	Move
COMP REQN1	Mean	300.25	100.00	0.00	0.00
	Std. Dev.	0.44	0.21	0.00	0.00
	Lower C.I.	300.08	99.92	0.00	0.00
	Upper C.I.	300.42	100.00	0.00	0.00
INV1	Mean	300.00	100.00	0.00	0.00
	Std. Dev.	0.00	0.17	0.00	0.00
	Lower C.I.	300.00	99.93	0.00	0.00
	Upper C.I.	300.00	100.00	0.00	0.00
NEW REQN	Mean	212.90	100.00	0.00	0.00
	Std. Dev.	12.56	1.41	0.00	0.00
	Lower C.I.	208.05	99.46	0.00	0.00
	Upper C.I.	217.75	100.00	0.00	0.00

*

APPENDIX D

LIST OF ACRONYMS

AVCAL	Avaition Coordinated Shipboard Allowance List
COSAL	Coordinated Shipboard Allowance List
CVN	Nuclear Powered Aircraft Carrier
DOD	Department of Defense
DSS	Decision Support System
GAO	General Accounting Office
GFE	Government Furnished Equipment
GFM	Government Furnished Material
ICP	Inventory Control Point
ILS	Integrated Logistics Support
NAVSEA	Naval Sea Systems Command
N/C	Not carried
NIS	Not in stock
NNS&DDCo	Newport News Shipbuilding and Drydock Co.
NSC	Naval Supply Center
NSN	National Stock Number
SCN	Ship Construction and Conversion, Navy
SMIC	Special Material Identification Code
SPCC	Ships Parts Control Center
SUPSHIPNN	Supervisor of Shipbuilding Conversion and Repair, USN, Newport News, VA.
TYCOM	Type Commander

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